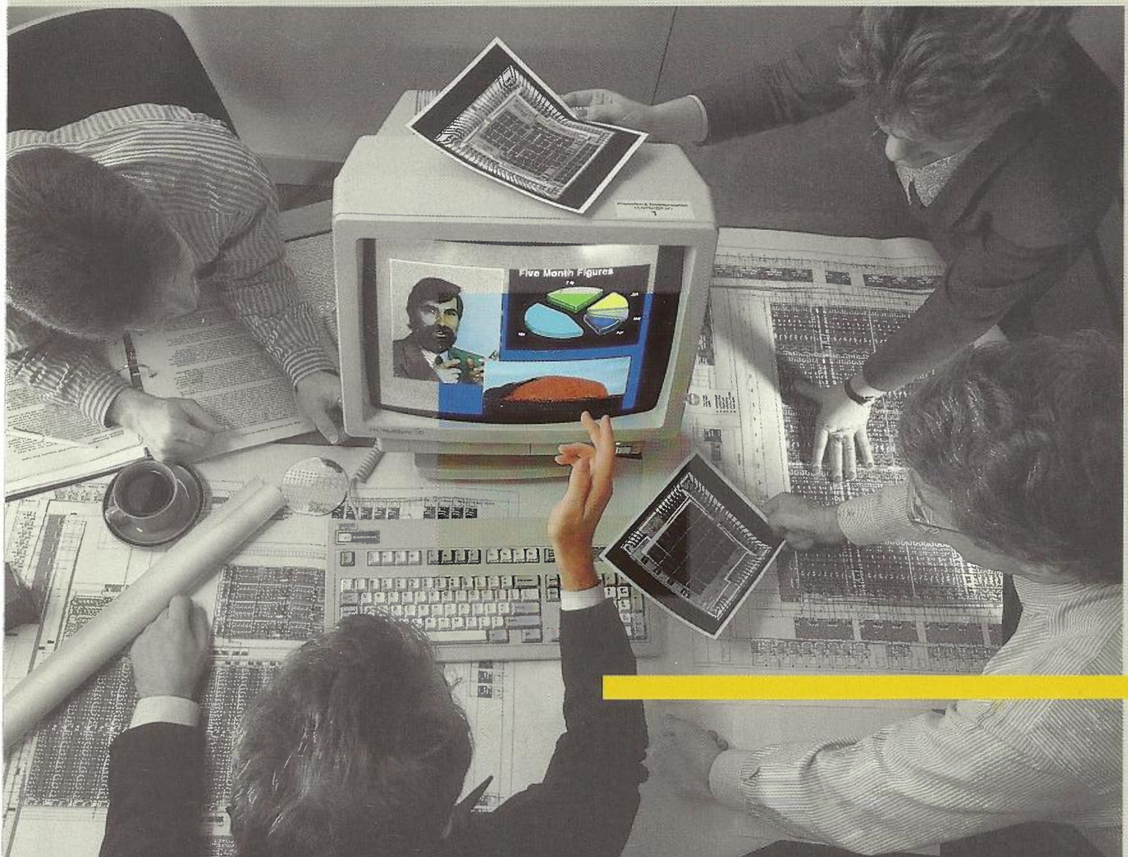
1992 REVIEW OF ACTIVITIES

TELECOM RESEARCH LABORATORIES



Telecom Australia
Research Laboratories

Australian and Overseas Telecommunications Corporation Limited A.C.N. 051 775 556

MISSION STATEMENT

To provide Telecom with technological and scientific leadership, knowledge and expertise so that it can be the best provider of telecommunications and information services.

Telecom Research Laboratories
770 Blackburn Road
Clayton Victoria 3168
Australia

Telephone
National (03) 253 6444
International 613 253 6444

Facsimile
National (03) 253 6789
International 613 253 6789

ISSN 0314-1357

FOREWORD

In 1992, Telecom Research Laboratories (TRL) continued to play a vital and significant role in Australia's telecommunications industry by thoroughly preparing Telecom for the onslaught of competition.

The dedicated men and women at TRL are no strangers to competition and have been preparing for it for some time. The broad spectrum of professional and support staff at TRL, ranges from physicists, engineers, mathematicians, and chemists, through to sociologists, geographers, and urban anthropologists. These researchers have already been competing for many years on a world scale to be the first with the best. Here, we have a coherent team of people who can successfully accomplish a meshing of technology with both current and forecast human needs and wants in Australia.

The technology introduction agenda is no longer controlled by orderly consideration of maturity and investment patterns. Now, it is very important to maintain a competitive edge by expediently delivering differentiated products and services to the customer.

The way in which we do research has also changed because there is no longer room for the luxury of waiting to introduce new technologies until we're 100 % satisfied that they are ready. But, by continually looking to improve the processes of development, standardisation and introduction, we can tighten up the delivery mechanisms and provide industry, business, and private customers with leading-edge products and services at an enormous pace.

The result of competition is a rush to TRL so that Telecom can maintain a firm market footing. The benefit of hindsight shows that the same thing happened to British TRL, NTT Labs, and Bell Labs when competition appeared. TRL anticipated this, and has been putting programmes in place to generate new skill bases and gain the necessary expertise to support Telecom.

However, it is no longer enough to provide world class and technologically advanced services. TRL must also ensure that Telecom Australia introduces quality technologies and services that more than satisfy the customer's needs, are on-line with what the customer wants, and are introduced in the right place, at the right time, for the right people.

Emanating from TRL's foresight, Telecom will be well placed to capitalise on advances in network reliability, increased flexibility and capability, smoother network management, core developments in switching, signalling and transmission, and better radio and fibre based services. All of these advances lead to the ultimate goal of complete customer satisfaction.

The following pages will give a pleasurable insight into the diverse range of R&D carried out at TRL, and will demonstrate that Telecom is well equipped to meet the demands and challenges brought on by the exciting stimulus of competition.

H. S. Wragge
Director of Research

CONTENTS

TRL MANAGEMENT COUNCIL

Harry Wragge
Director of Research

Michael Chirgwin
Manager
Financing & Computing Services

Brian Donovan
Manager
Promotion & Communication

Trisha Farnes
Manager
Human Resources

Alan Gibbs
General Manager
Transmission Networks & Standards

Owen Malone
General Manager
Intellectual Property & Information

Geoff Mitchell
General Manager
Telecommunication Science & Technology

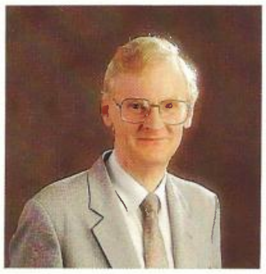
Don Nicol
Chief of R&D – Sydney

Jim Park
General Manager
Switched Networks

Helen Rodd
General Manager
National Information Resource Centre

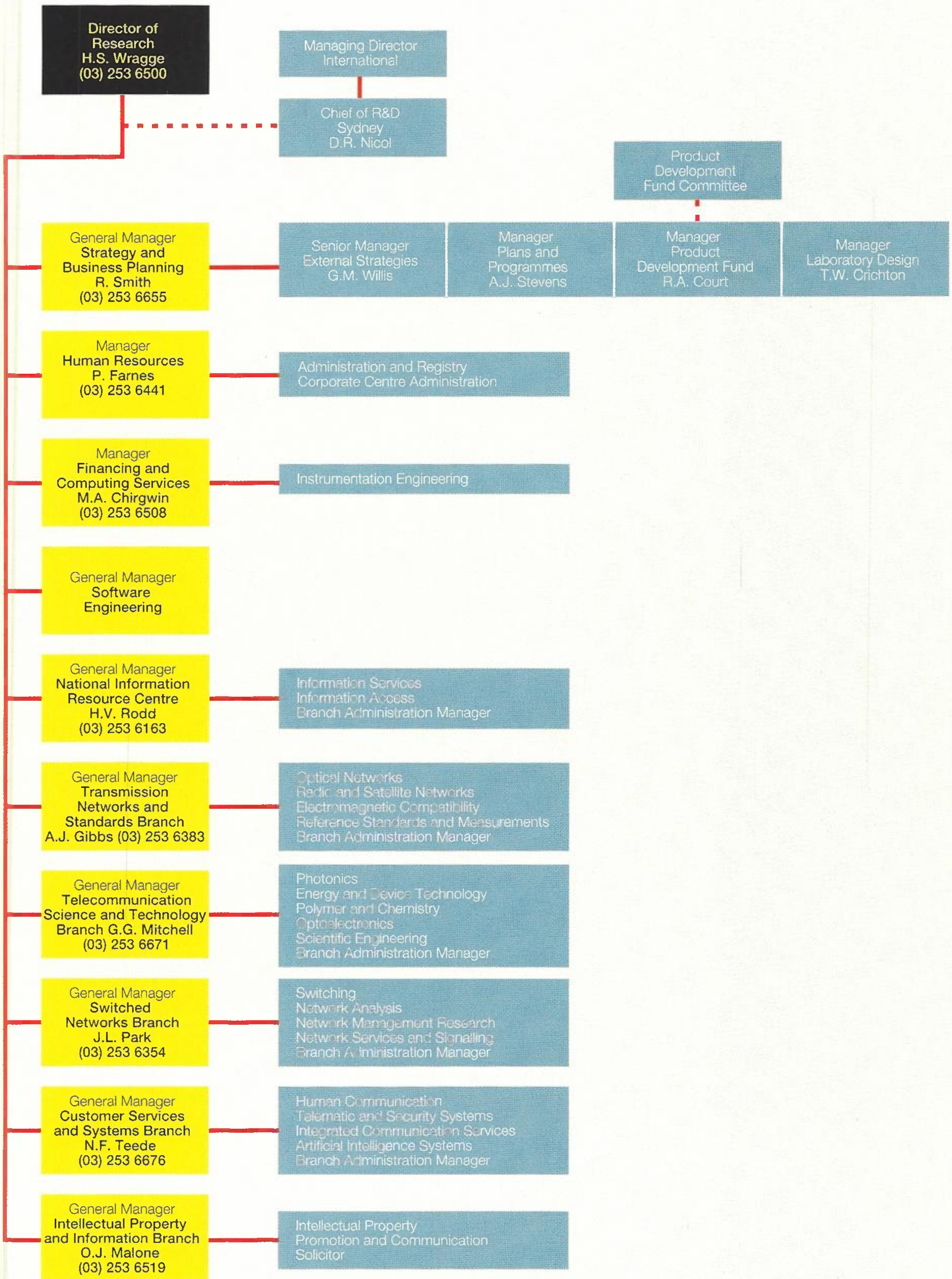
Roger Smith
General Manager
Strategy and Business Planning

Noel Teede
General Manager
Customer Services and Systems



Geoff Willis
Senior Manager
External Strategies

ORGANISATIONAL CHART



TRL provides a strategic resource which is a key to Telecom Australia's technological leadership.

AN OVERVIEW

Achieving the Mission

TRL seeks to provide expertise which will allow Telecom to be an intelligent and sophisticated procurer and operator of high level technology in meeting the telecommunications needs of its customer.

TRL's mission is being achieved through seven key areas:

- provision of strategic advice and expert consultancy,
- value adding to Telecom Australia's products and services,
- cost reduction of Telecom Australia's equipment, systems and networks,
- technical support of Telecom Australia's existing plant and equipment
- transfer of technology to other parts of Telecom Australia,
- increased ownership of Telecom's products through system and component design, and
- maintenance of a highly skilled, expert and motivated work force.

A Business Unit of Telecom Australia

TRL is a business unit within Telecom Australia. It is responsible for performing Telecom Australia's research needs. TRL conducts a research programme derived from a corporately endorsed and approved business plan. Complementing the research programme, TRL also provides a number of corporate facilities for the company. These include the Telecom intellectual property portfolio, the provision of a Telecom-wide information resource, and the conduct of a programme of support to academe. The services that TRL provide are available to all other organisational units of Telecom Australia.

The annual formulation of the business plan requires the consideration of corporate priorities and performance needs of R&D projects and related activities. This is in terms of the required "deliverables" and the resources needed to ensure their timely delivery. A requirement is that 85% of the research programme is funded by other business units of Telecom. The other 15% is discretionary and contains more forward looking work that business divisions are not yet ready to fund.

The Role of TRL

Through the performance of research, development and related activities, TRL provides a strategic resource which is a key to Telecom Australia's technological leadership.

Expert Advice

TRL's advice regarding the application of new and existing technologies ensures that Telecom Australia is best able to provide up-to-date services and a highly reliable network. It does this by providing strategic advice concerning opportunities for exploiting potential new technologies and new generic services, and by transferring technology to other parts of Telecom, Australian industry and academe. In addition, TRL supports existing network technologies by enhancing reliability, reducing operational costs and improving performance. Furthermore, TRL strives to increase ownership in Telecom Australia's products, both at system concept levels and through specialised device design.

Collaboration

Collaboration between TRL and industry ensures that systems and equipment are cost-effective and reliable. TRL's collaboration with universities helps tailor appropriate telecommunications skills for future graduates.

Standards

Participation in the development of technical standards ensures that they operate to the greatest advantage for Telecom's requirements. TRL provides delegates to participate in the development of national and international standards relating to telecommunications. In this way, TRL can represent both the interests of Telecom Australia and Australian industry in national and international forums. TRL's technical experts are able to debate complex issues from a position of in-depth knowledge and expertise, and can thus influence the development of standards to be in harmony with Australia's telecommunication needs. These forums are also a source of strategic information regarding future trends in service provision and system development. TRL is thus able to advise Telecom Australia on the current status of technical standards and the probable directions of evolving standards. Telecom can then apply standards in a timely manner with assurance that they are the most up-to-date, thereby making the applications credible and viable. TRL can use this information to their advantage by developing tools that will optimise the application of new standards.

Corporate Facilities

As an adjunct to the performance of the research programme, TRL manages and provides several specialised corporate facilities for the whole of Telecom Australia. These include:

- The operation of the National Information Resource Centre (NIRC), which provides up-to-date library and information services covering a wide range of topics relevant to Telecom's operations.
- Intellectual Property Consultancy, including the management of Telecom Australia's intellectual property portfolio.
- A programme of support to academe, principally via the establishment of Centres of Expertise in relevant areas of telecommunication study at appropriate universities. This programme complements the internal research programme and includes undergraduate and post graduate fellowships provision, as well as support via the Australian Telecommunications and Electronics Research Board.
- The maintenance of Telecom's reference standards in relation to the physical measurement of optical and electrical quantities, to enable Telecom to meet its obligations under the Weights and Measures Act.

TRL Management

The business plan is the key stone of the management of TRL. It provides the vehicle for determining which projects will be included in the annual research programme and what resources will be allocated for their performance. It also provides a basis for the individual Branches of TRL to derive more detailed work programmes and to monitor project progress and associated resource expenditures.

The business plan is reviewed and reformulated annually as part of the corporate business planning process. It comprises a rolling five year strategic plan, which establishes major R&D thrusts and the direction and magnitude of the TRL programme. Additionally, a more detailed one year operational plan is formulated and includes specific research detail and budgetary allocations.

The formal annual consultation processes leading to the endorsement and approval of the business plan ensure that:

- The research programme derived from the business plan is cost-effectively related to corporate needs for research outputs.
- A balance is struck between shorter term projects relating to client needs and longer term projects necessary to maintain the ongoing viability and skill base of TRL.
- Accountability for technology and information transfer is a clear responsibility of TRL.
- TRL maintains an up-to-date technical skill base which can be rapidly re-deployed to meet sudden emergent and strategic needs.

TRL Strategic Technological Thrusts

In assembling its R&D programme, TRL has integrated the technology needs of the Business Units into a series of technology thrusts which comprise TRL's internal strategic technology directions. These are:

Personal Communications

To use radio and fixed networks to provide new and widely available personal communication services.

Optical Fibre

To introduce optical fibre into the Customer Access Network in a cost-effective manner for narrowband and new broadband services. Furthermore, to provide a high capacity, low cost trunk optical fibre network.

Human Social & Business Needs
To develop and provide methodologies and knowledge about the communications needs of Telecom's customers in their business and social activities, that will enable Telecom to specify, plan, and provide quality telecommunications products and services to satisfy those needs.

Broadband Packet Switching
To provide flexible , broadband packet switched networks capable of carrying a very diverse range of traffic.

Network Management
To provide capable network management systems for both Telecom and its customers.

Signalling for Personalised Services
To develop sophisticated signalling systems for network services including personalised and mobile services.

Customer Service
To provide technology that will allow customers to realise enhanced value from network services concerning information, image, video, voice activated and multi-mode communication,and position Telecom to provide total service packages.

Artificial Intelligence
To improve operating efficiency by incorporating artificial intelligence systems in critical operations and design systems. And to create a new generation of network services that employ artificial intelligence to make them accessible to the broadest number of customers.

Reliability
To improve the reliability and performance of the Telecom network and business products.

Advanced Material
To conduct research into advanced materials and devices that are of strategic importance to future telecommunications systems.

Safety
To develop the scientific bases for safe practices with work place hazards.

Security
To provide security technologies that will meet the differing needs associated with protecting Telecom's infrastructure and customer services.

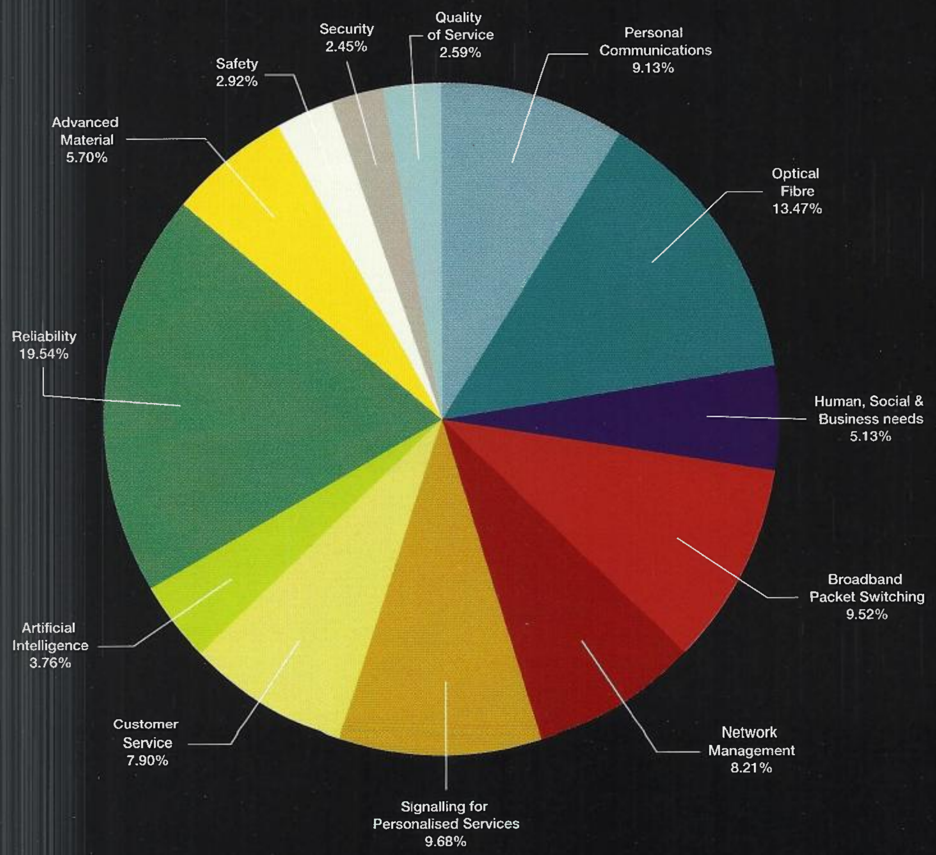
Quality of Service
To provide the quality of service that is provided by our customers for their applications.

Resources

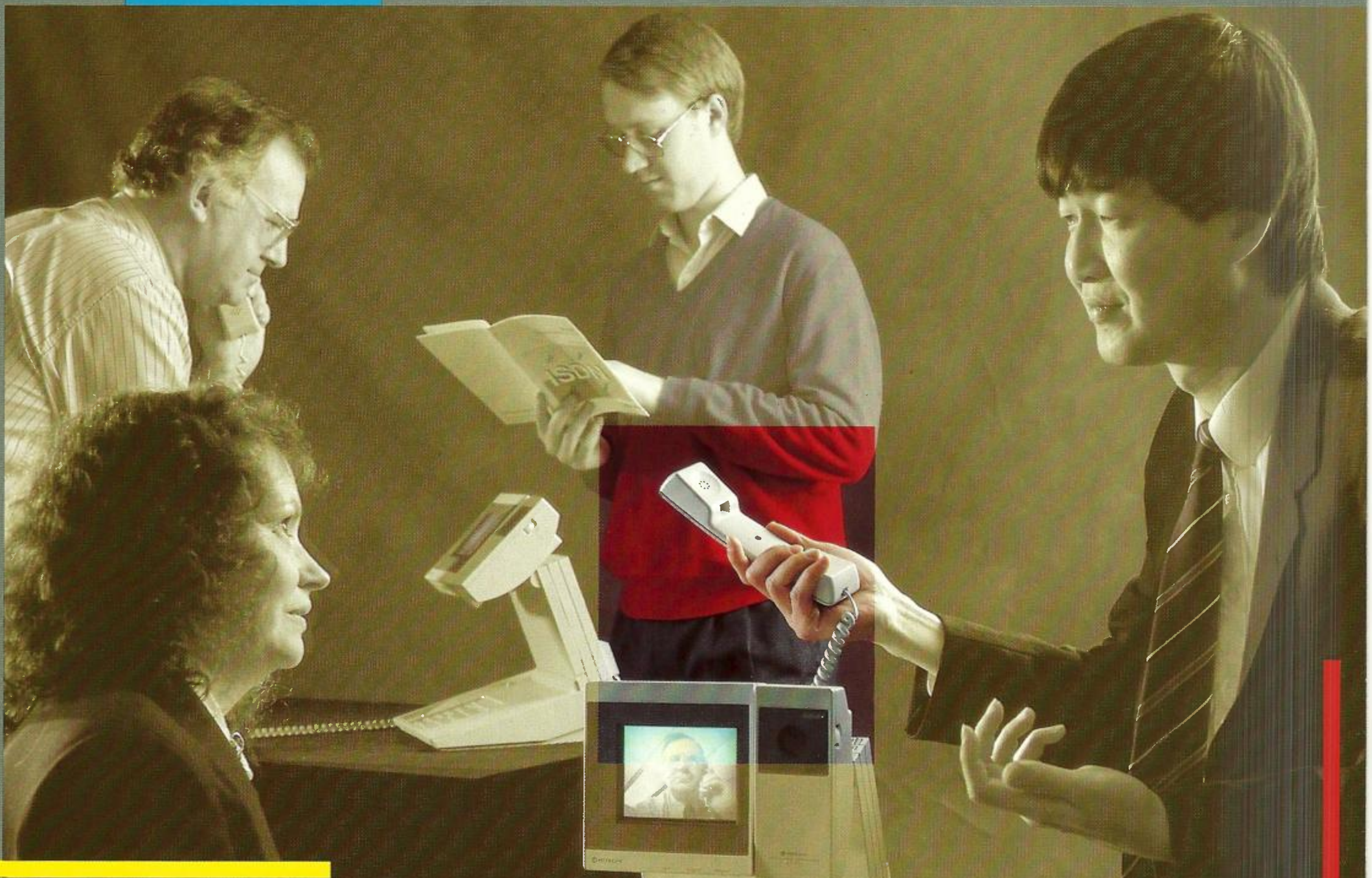
During 1991/92, TRL employed approximately 560 staff. Of the total staff, approximately 310 have professional qualifications, the majority in engineering or the applied sciences and 50 in the social and information sciences. A further 140 technical staff supported the professional staff, with administration performed by remaining staff.

The annual operating costs of TRL totalled approximately $64 million. Of this total, about half is expended on salaries and salary-related costs. The remainder covers operating expenditures on consumable materials, incidental items (including R&D contracts), and buildings and building services. Capital expenditures, primarily on laboratory test equipment and facilities, amount to about $5 million annually. Laboratory test equipment items number about 16,000, with a depreciated value of approximately $9 million.

Research Programme by Technological Thrusts 1992/93



Future telecommunication services will be more customer focused, interactive and dynamically visual.



CUSTOMER SERVICES AND SYSTEMS

Future telecommunications services will offer major advances that will change the way people conduct their business, and improve the quality of their social lives. Services will be more customer focused, interactive, and dynamically visual.

The Customer Services and Systems Branch is involved in a broad programme of leading-edge R&D aimed at providing new service and product opportunities. The skill-base ranges from multidisciplinary human communications specialists who understand the customer's communications needs, through to applications specialists in distributed information databases. We also have experts in communications security, intelligent support systems, speaker interactive services, and multimedia systems integration technologies.

These skills are brought together in teams of specialists for the creation of new services which enable customers to exploit information resources to the fullest.

Telecommunications will provide the means to identify, access and retrieve data from a broad range of sources and in a range of forms appropriate to customer needs. Such needs will increasingly drive the service applications and delivery networks.

Customer needs rather than technological availability will determine telecommunications services of the future. Technology is approaching the stage where almost any telecommunications service that can be imagined can be achieved. With the proliferation of service delivery and network options, cost, in terms of both infrastructure capital limitations and the willingness of customers to pay for those services, will increasingly set the limits in the future.

Immediate customer drivers arise from three main areas: First, the concurrent developments in low cost desk-top computing and related multimedia services; second, from the need for broadband networking of remote information held in distributed databases; and finally, from the need for customised services and service mobility. This is being reflected in increasing R&D efforts in visual, interactive and personalised communication services.

These customer drivers will ensure a changing service traffic mix favouring a relative growth of enhanced data service traffic at the expense of plain voice traffic. And within voice traffic, there will be an increasing proportion of mobile service access and delivery. The increasing amount of data stored as digital audio, text, graphics, image and video will ensure a steady evolution toward digital broadband services and networks.

Against this backdrop, Telecom Australia is investing heavily in customer services and systems R&D. If this great diversity of expected service opportunity is to be truly customer focussed, we need to understand the customer's end-to-end service needs. Then we must deliver those services competitively with world class quality.

Items on the following few pages illustrate some of the customer oriented R&D activities which emphasise the personalised, interactive and visual nature of expected future services.

Telecommunication is not just Technology!

"..and its all here, there [are] all these damn little things to press,...

it's a bit like a sewing machine with all the gadgets on it. ...I mean I think

there's always more potential than one uses, unless you're real smart; it's the same with the computer."

These words of a Telecom customer were spoken in an interview with a TRL researcher. A goal of TRL is to ensure that Telecom Australia introduces quality technologies and services that are better than what the customer expects, are matched with the customer's needs, and that are introduced in the right place at the right time for the right people.

This is why a team of human communication researchers have been learning how customers use telephones and how we in Telecom can help customers make the best use of the telephone in their daily business. The use of information flow methodologies had led us to an energetic, articulate and experienced business woman with wide ranging community interests. The above vignette from the interview with her, captures the response of many people who are faced with the multitudinous options provided by modern telecommunications. The technological foundation of modern telecommunication services is undisputed. However, these words, and many more recorded by TRL researchers, show that technology is not enough to ensure that customers are satisfied with the telecommunication service they are offered – the human side must also be heard.

A team of human communication researchers at TRL is examining how Telecom Australia can help customers make the best use of the telephone in their daily business.

The words quoted above resound with an underlying uncertainty felt by many customers. They present a challenge to Telecom to 'get it right' when offering telecommunication and information services in the market place. Information flow studies by TRL researchers are helping to identify what customers think their communication needs are, either existing, or being generated by the new ways in which customers want to do business. For example, a large organisation has been trialing video conferencing among its executives. Our study of this business video service is to chart the changes in information flows as they occur. The aim of the study is to match the functions, facilities and performance of the service to the needs of that business, which is in the throes of increased competition, economic downturn, and internationalisation.

Not only must we provide the functions that will enable people to be more efficient and productive, but we must help individuals to be 'real smart' in dealing with Telecom's products and services. The usability of the services offered must match the customers' knowledge and particularly the time they have available to invest in taking a new capability into their communication toolkit.

Human factors researchers have helped make the interface to various Easycall products usable, by designing and evaluating documentation and user control procedures. This research has generated knowledge that is being incorporated into a set of guidelines for designers to use when deciding on interfaces to new products. These guidelines draw on international information as well as our own research and will be thoroughly field tested before being released. They are part of the process that will produce a Telecom 'look and feel' which will signify quality to customers.

The best technology and most functional services are useless if they are not in the right place. Where is the right location for the networks and service capability? Geographical analysts in TRL are developing methods of spatial analysis, using the information processing power of computers to answer this question. For example, Customer Logical Network Mapping provides a means of analysing the spatial data describing a customer's current communication activity. It then relates this data to other factors like population distribution, markets, business activity and infrastructure. The aim of the work is to develop a tool that can facilitate the planning of new networks and services that fulfil the requirements of the customer for an evolving communication capability.

Human communication research at TRL ensures that Telecom provides telecommunications which customers judge as being of world-standard quality. We do not want customers to talk about Telecom in the same way that a manager of an engineering firm spoke of computer salesmen: "Nobody ever comes to me and says 'If you install this computer it can do this for you.' People will only come and say to you, 'If you install this computer it's got a processing speed of 20 megabytes; isn't it fantastic?'"

Rather, we want our customers to be like the one who told us, 'I'm a fan of Telecom ... This is the model that Telecom supplied me ... I think it's for the blind or visually impaired, there's that little raised bit, feel it, in the middle of each number ... I think it's very clever.'

Artificial Intelligence for Future Voice Interactive Services

Artificial neural network learning techniques developed at TRL are being applied to produce cost saving methods of natural language voice recognition that will enable inexpensive customer information services with a perceptively simple customer interface.

With advances in speech recognition systems, many new voice interactive services become possible. A typical example is an interactive information system. An information request in free form natural language has many advantages for customers. They do not need to be aware of the structure of the information service, nor learn an interface command procedure. A simple request in context is a very robust means of communication between people. If a customer enters a used car parts store and simply states "Holden power steering", the salesperson would have no difficulty in understanding the request. Similarly, if we enter a travel agency and say "cheap flights to Hong Kong", there would be no difficulty with the conversation.

The successful communication of a request or comment is dependent on a mutual understanding of the context. In these examples, the context is at least partly provided by the physical setting. Someone who walks into a used car parts store and says "cheap flights to Hong Kong" will face some difficulty in communicating. Exactly how we describe a context for communication is very difficult, but very important.

To provide information to customers at a reasonable cost, it is desirable for them to interact with some kind of automatic service. It will take some time for speech recognition to provide extensive capabilities for natural language interaction. But by limiting the context, and hence the extent of the vocabulary, simple natural language interactive services are now possible with either voice or keyboard input.

When a customer makes an enquiry in a shop, the context is immediately clear from the physical setting. But talking over the phone or via a keyboard is completely free of any context. In this situation there is a potential for great misunderstanding. It is preferable to have an indication of the context, even if that indication is only approximate. In a human-to-human conversation there are many other cues available, but in the artificial setting of a customer talking to a machine, the only cues available are from the words themselves.

To establish the context, it is useful to categorise the language used by a customer. In our example of "cheap flights to Hong Kong," the use of the word "flights" is a strong indicator that the context is travel, and the use of a travel destination reinforces this choice. Knowledge of the most common use of words can be very useful as a guide to the context. Given a large set of words together with an indication of their likely context, we can determine the actual context.

Existing methods of determining context rely on indications constructed by hand which are expensive and time consuming. A cost saving method of construction developed at TRL makes use of artificial neural network learning techniques to determine the context. All of the words relevant to a particular context are encoded into a neural network which can then be used for determining context. Most importantly, the network is constructed automatically from a detailed analysis of text relating to that context. Thus, by analysing documents relating to the travel industry, we can automatically construct the neural network that gives a "travel" context indication.

To use the context neural networks, the customer's query is presented to a large set of networks that indicate various contexts. Candidates for the context are selected if their corresponding neural networks are strongly activated by the customer's words.

In contrast to existing approaches, the context selection is very rapid and much cheaper to construct.


Data file: cusj1001
969 milliseconds
xmax = 40000
(dx = 10000)
ymax = 10000
(dy = 1000)

Speech Recognition

Speech recognition is a key to providing a vast number of telecommunications customers with a necessary and useful service that will save both Telecom and the customer time and money whilst offering a new information avenue to people such as the visually impaired. Expert R&D carried out at TRL is increasing the quality and extent of speech recognition for telecommunications services of the future.

Speech recognition can be defined as the identification by computer of spoken words. It is of particular interest as a natural interface between man and machine. The complexity of the recognition task depends on factors such as –

- Telephone quality versus higher quality speech.
- Speaker dependent versus speaker independent recognition.
- The size of the vocabulary to be recognised.
- Continuous versus isolated word recognition.

Most network-based speech recognition applications involve speaker independent recognition using telephone quality speech with varying degrees of acoustic background noise. For example, applications that involve the entry of long digit strings, such as card and telephone numbers, benefit considerably when using continuous digit recognition.

A wide range of interactive voice response and voice messaging applications are now being implemented using large training databases of speakers repeating a small vocabulary of words. Early applications using digits and a small number of control words are proving successful, provided careful consideration is given to the human interface issues.

As the vocabulary size increases, so the recognition task becomes more difficult.

For vocabularies upward of 1000 words, speaker independent recognition systems need to be a lot more refined. TRL is taking a number of approaches to this problem. There is fundamental research being undertaken to recognise parts of words (sub-words) in conjunction with a "dictionary" of rules that describe how words are composed of their parts. Each sub-word is represented by a statistical model, known as a hidden Markov model. Artificial intelligence techniques are also being applied to add contextual and prosodic information to limit the likely word choice and infer meaning and intent to the words recognised.

Longer term speech recognition research will eventually provide a conversational man-machine interface, a feature that will be necessary for the automation of more complex interactive telecommunication services of the future.

Dr Michael Flaherty of TRL is analysing voice waveforms for the purpose of developing voice recognition capabilities so that Telecom Australia can provide customers with new and improved service options that are faster and more economical.

Spoken Language Understanding Systems

TRL has developed a spoken language understanding system that combines speech recognition, natural language understanding and neural network technologies. The result is a practical service platform with immediate customer and business applications.

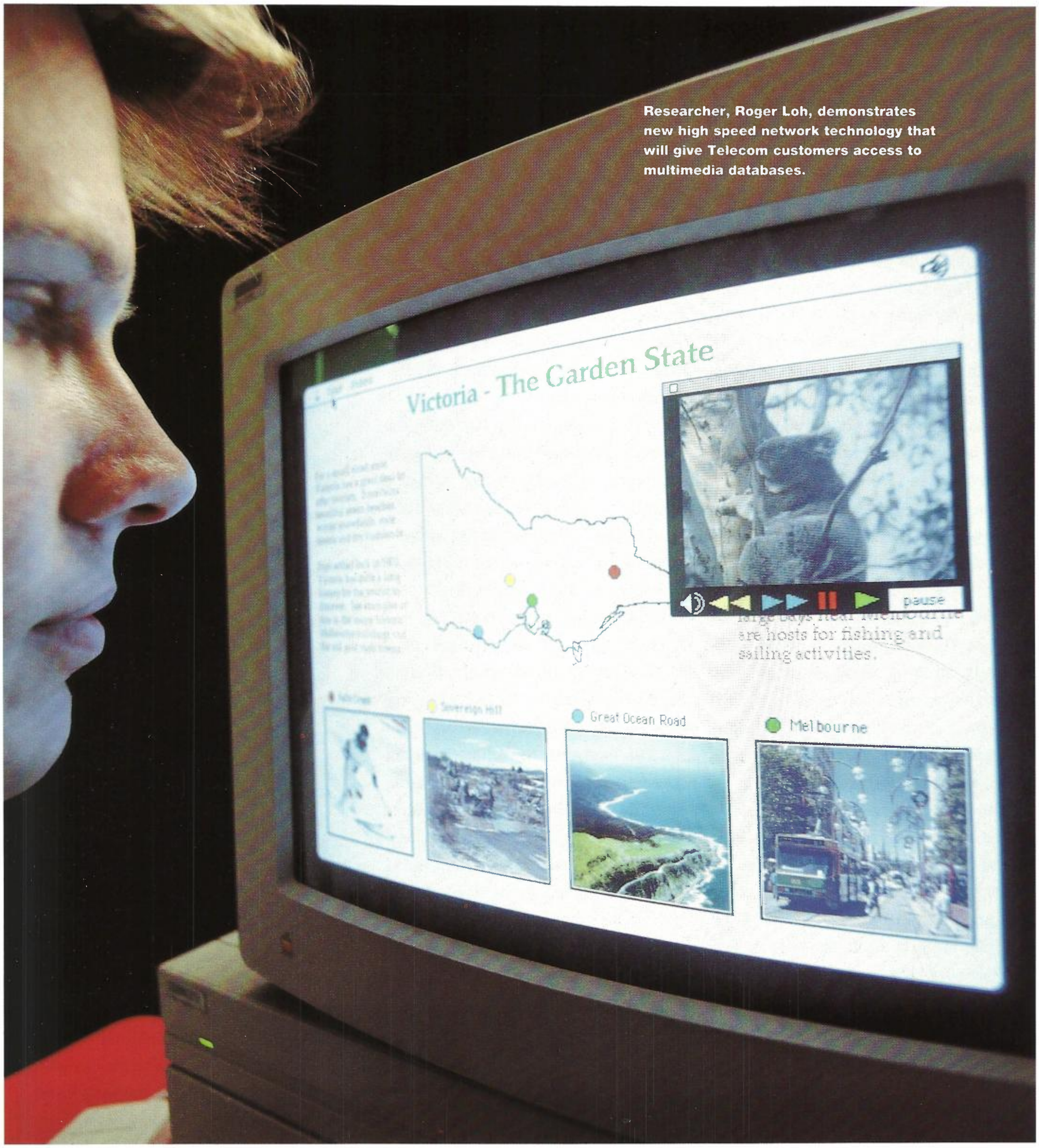
One system implementation, called Groucho, provides telephone callers with information on films currently showing at their local cinemas. Upon dialling, callers are asked the desired cinema location, viewing date and film genre. The system responds with a list of suggested films, locations and times. Callers may then change any part of their selection and receive other suggestions.

Groucho makes the most out of a small vocabulary and simple speech recognition technology by using natural language understanding techniques to model the structure of information-seeking dialogues. The dialogue model also limits the search for the correct words from the speech input by initially searching only for words that are expected at that point in the dialogue. If a good match is not found, then other progressively less likely words are tried. The word recogniser in this case uses artificial neural networks because of their recognition speed and training simplicity.

The particular class of neural network used in Groucho was developed at TRL with a structure especially designed to simplify implementation. Together with simplified signal proc-essing, Groucho can be implemented using low-cost hardware. It is currently implemented on a standard personal computer and uses commonly available plug-in cards for speech digitisation and speech generation.

While Groucho is a demonstration of a cinema information service, the spoken language understanding technology it contains can be applied to a wide range of other applications. In particular, Groucho demonstrates how a practical system can be constructed by combining simple technologies in the right way.

Immediate customer and business applications can be seen with TRL's development of advanced computer-based voice recognition services over Telecom's network.



Researcher, Roger Loh, demonstrates new high speed network technology that will give Telecom customers access to multimedia databases.

Expanding the Video and Multimedia Service Horizons

Improvements in network capacity and data compression rates have allowed researchers at TRL to examine the reality of new practical video and image-based service opportunities over the current telecommunications network and over future high speed networks.

TRL is also playing a significant role in the standardisation of video communication for the Broadband ISDN. Collaboration with universities and industry is helping to establish a pool of Australian expertise in this field, to take advantage of expected future growth.

Visual communication has always been a challenge because so much information must be transmitted. For example, a single high quality colour television picture in digital form contains around 40 times as many bits of information as are transmitted for a single fax page. High quality motion television signals have several hundred times the transmission rate of a telephone circuit.

Motion video research at TRL includes everything from domestic videophones to High Definition Television (HDTV). Videophones are now viable over the ordinary telephone network for the lower quality service and over the ISDN for the higher quality service. High quality videoconferencing has been demonstrated over the very high capacity Broadband ISDN. TRL's research includes the carriage of HDTV which may require several hundred times as much information as a videophone service to maintain almost perfect pictures.

One of the most significant advances of recent times in computer technology is the capability to manipulate and present "real-time" information, such as video and audio, images, text, and graphics. This multimedia capability is leading to exciting developments in interactive access of information. For example, a tourist information service might provide maps, pictures, video and audio, and text information about holiday destinations. TRL has transmitted this kind of information between capital cities over Telecom's Fastpac network for presentation on a single integrated terminal device.

If this range of sophisticated services is not enough, TRL is already considering the networking needs of future services based on Virtual Reality, where users immerse themselves in a computer generated world of stereo vision and sound.

Automatic Network Design and Costing Tools

TRL has been producing a range of software tools to optimise customer network design and to enable sales staff to more efficiently produce reliable and repeatable quotes for Telecom Australia's data networks.

These decision support tools go by the name "Telequote". They give Telecom's sales staff the ability to concentrate on delivering the ideal solution to the customer and ignore the tedious and mechanical aspects of producing a quote.

The Telequote tools also offer features to sales staff that were not available using other techniques. The most important of these features is the ability to optimise a network design, thus minimising the cost to the customer. This optimisation process is complex, difficult, and almost impossible to perform by hand. The customer can now be sure that the best combination of services is being provided by Telecom at the lowest possible cost.

The Telequote tools have been implemented as a number of programs that run on IBM personal computers. To date, two tools have been developed by TRL; one for Telecom's Digital Data Service, and another for Telecom's Integrated Services Digital Network. Development is complete and the programmes are supported through Telecom's Business Systems Unit and by Telecom's Information Technology Group. In addition, TRL is currently developing a tool for Fastpac, and the Information Technology Group is completing the development of a tool for Austpac.

TRL has now begun work on the next phase of development – a generic network design and costing tool. The generic tool will significantly reduce the development time for new Penee tools. It consists of a part to perform the network design and optimisation, and a part to perform the network costing. A computer language is being developed to allow the generic specification of any service that Telecom sells. The language will simplify the construction of code for the cost optimisation over a range of network service options and tariffing structures.

The generic network costing and design tool will be used by the Business Systems Unit in future Telequote tools to give Telecom's customers consistent and high quality support at the lowest service cost.

Image Database Systems

Image services research conducted at TRL, including the application of advanced image coding techniques, demonstrates the reality of services such as home shopping over the existing telephone network. TRL has also established the almost instantaneous transfer of high quality color images across the country on Telecom's Fastpac network.

The ability of the Public Switched Telephone Network (PSTN) to carry data traffic continues to increase as data modems of higher speeds become available. Modems can now operate at speeds of 14.4 kbits/s, and other high performance networks such as the ISDN are now available using channels that run at 64 kbit/s. Currently on trial, the Fastpac network will offer a 10 Mbit/s digital interface to customers.

A new standard describing a method for compressing images has been produced. It was developed by the Joint Picture Expert Group (JPEG) in the International Organisation for Standardisation and the International Telegraph and Telephone Consultative Committee (CCITT). The standard supports both lossless and lossy coding of images.

Using lossless coding, image quality remains unaffected by the coding process. However, compression levels are only possible in the order of three to one. The lossy scheme offers much higher compression levels, typically in the order of twenty to one, but if poorer picture quality is acceptable then levels in the order of fifty to one are possible. A twenty to one level is generally accepted to offer a good level of compression with minimal subjective degradation of image quality.

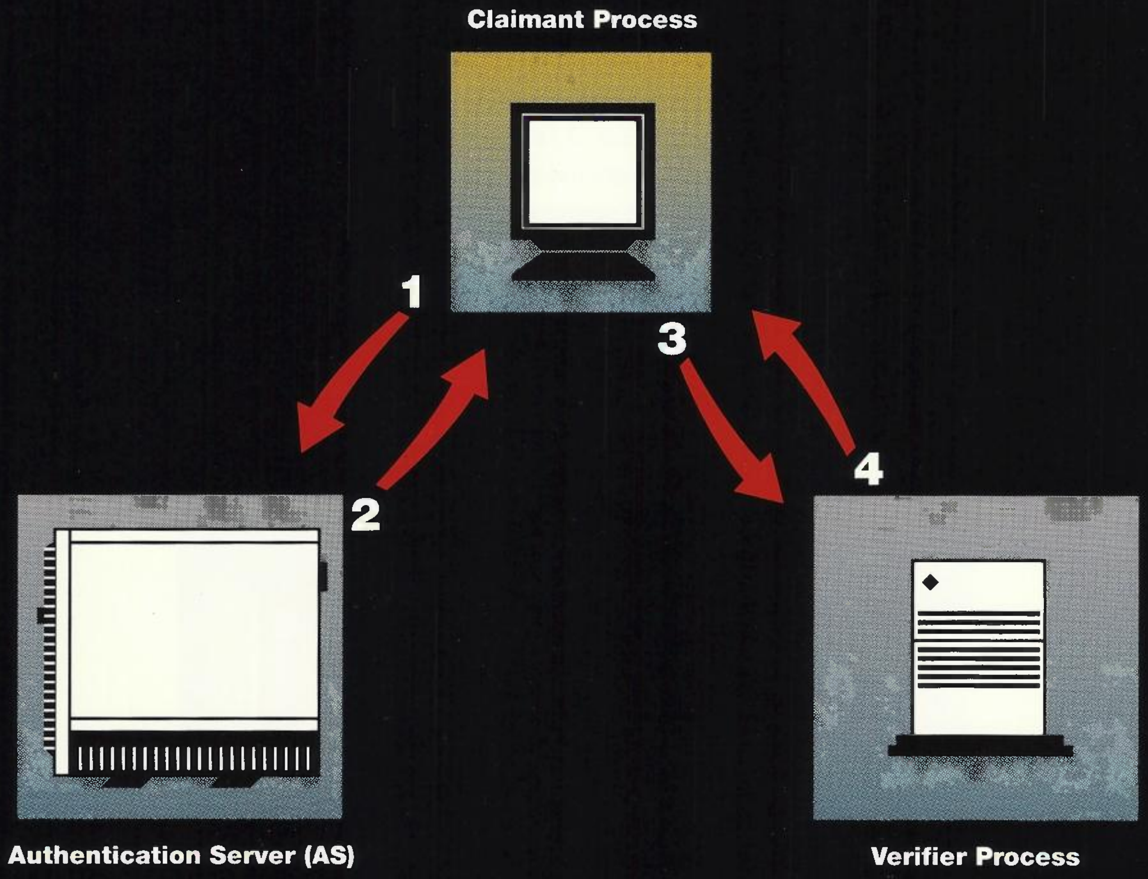
JPEG is available in both software and hardware implementations. While the hardware implementations are faster in operation than the software implementation, there is no longer an order of magnitude difference in the performance. As personal computers increase in power, the performance of the software approach will continue to improve to enable the cheap implementation of image systems on personal computers. TRL has completed a personnel image database which uses a hardware implementation of the lossy version of the JPEG algorithm. The database can operate over either an ethernet local area network or Fastpac.

Currently under development is a new tool to support rapid prototyping of image database services, which could operate on ethernet or Fastpac. In addition, this tool could also provide a simulation of the service as though it ran over the PSTN or ISDN. It will have the capability to support both a hardware or software implementation of the lossy JPEG algorithm. Thus making it possible to rapidly determine the feasibility of potential image applications in particular market sectors. The service can then be tailored to suit perceived customer needs.

Once the market has been identified, a real service can be constructed with accurate knowledge of the market needs.

Colour images that can be transmitted over Telecom's existing telephone network will actuate new service applications such as this example of home shopping.

Authentication Framework



The sequence of events for authentication is as follows:

1. The Claimant Process requests authentication information from the Authentication Server.
2. Two certificates – one for the Claimant Process and one for the Verifier Process are returned.
3. Based on its certificate, the Claimant Process will generate an authentication token and transmit this together with the verifier certificate to the Verifier Process.
4. The Verifier Process is able to use the certificate and the token to determine the identity of the claimant. To achieve mutual authentication, a token is transmitted back to the Claimant Process.

Access Control for Network Management

TRL is actively developing an authentication service for the many Telecom customers who require a high security level. The authentication service will be suitable for resources managed within the Telecommunications Management Network (TMN) which allows network resources of varying intelligence from different vendors to be managed by Telecom through a common interface.

The TMN is defined by International Standards and is essentially a large, highly distributed information processing application. It requires many simultaneous data links to be set up so that management information within the whole network can be accessed, sent and modified. Furthermore, the integrity of the whole network may depend on this data being accurate. For example, a request that either unintentionally or maliciously shuts down a critical network link could cause chaos by severely degrading network performance. In addition, the TMN contains a large amount of sensitive data that should be protected from disclosure. An access control service protects the TMN from both these risks. This service checks whether the originator of a request to modify the network, is authorised to do so.

The most important aspect of the access control service is checking the identity of the originator of any request. This is known as authentication and is seen to be so important that simple password methods are regarded as too weak. A stronger form of authentication using cryptography is needed. Authentication based on conventional cryptography requires that some secret information be uniquely shared between parties before authentication can take place. The problem for TMN is that with a large number of different parties needing to communicate with one another, the amount of shared secret information necessary for direct authentication is too large to manage efficiently.

The architecture that TRL has adopted for authentication is that of a distributed network of authentication servers. Each server is responsible for the authentication of all the entities it controls. The authentication process involves the appropriate use of encryption mechanisms in conjunction with timestamps and random numbers to create a one-time password. Passwords are calculated and verified without having to share information between authenticating parties. As information is only shared with the authentication server, the amount of secret information needed is dramatically reduced.

Not all network elements possess fast and powerful processors. This places constraints, especially computational constraints, on the mechanisms that implement the authentication scheme, such as encryption. However, it is also important that these constraints do not unduly compromise the strength of the authentication scheme . The authentication protocols must also be developed to fit into the appropriate Open Systems Interconnection communications protocols. With focus on such considerations, TRL is actively developing an authentication service at a high security level, which is suitable for resources managed within the TMN environment.

Reliability in the delivery of a public service is of paramount importance to TRL.

RELIABILITY, QUALITY AND STANDARDS

Amongst all the change processes that roam so freely around the world of telecommunications, one concept stands firm within TRL – the paramount importance of reliability in the delivery of a public service.

Although our culture worships novelty and espouses adventure as a means to personal growth, the truth is that admiration of the unexpected is mostly made from the vantage point of reliable comfort. The bored driver of a modern car in dense traffic can suddenly evince a keen interest in the reliability of contemporary integrated circuits if his electronic engine manager breaks down halfway across an arterial intersection. Approached at that time he may even be prepared to make a contribution towards research into the topic.

The rarity of such breakdowns is something of a modern miracle when you consider the increasing complexity that is needed to satisfy the discerning customer. Indeed, hardware reliability has improved to the extent that complaints about software are much more common amongst those who like to mix computing with communications. This high level of device and circuit reliability has not come about by chance. Spare a thought for those of TRL who devote their lives to understanding the finer points of reliability in telecommunications. So much more than just technical expertise is required to keep quality and standards from falling prey to market forces. Equipment must deliver its promise as designed, and be robust enough to withstand human treatment, but gentle enough not to harm a customer – even if provoked.

The following pages demonstrate the demands placed on our reliability investigators who require a double-edged form of creativity. First, researchers must fast-forward natural processes to provoke the most subtle of failures in a reasonable time. Second, they must devise cost-effective solutions which can be experimentally verified beyond any reasonable doubt. All this is done, with a high level of predictive power, over a range of activities that extend from the vastness of the great outdoors, to the microscopic insides of integrated circuits.

Leap Seconds in Telecom's Time

On 30 June 1992, TRL adjusted Telecom Australia's time services back by one second to compensate for the difference between the atomic sourcing of time and the solar second. It was a world wide adjustment co-ordinated by the Central Bureau of the International Earth Rotation Service (IERS), located at the Paris Observatory.

TRL maintains the time standards for Telecom Australia who is the major guardian and provider of time services in Australia, including the Dial-It speaking clocks, hourly time signals to radio stations, and the civil time serial time code distribution.

Until 1956, time scales were based on the earth's rotation about its axis, ie; the length of the day. However, irregularities in this rotation led scientists to search for a more constant and accurate basis for time. In 1958, atomic clocks based on vibrations of the caesium 133 atom were used to provide a precise time scale.

An international time scale based on a new definition for the second in terms of these atomic clocks was introduced and is known as Co-ordinated Universal Time (UTC). This replaced the Greenwich Mean Time (GMT) system which was based on the solar second.

The IERS is responsible for determining when an insertion of a "leap" second into the UTC time scale is necessary to maintain an approximate relationship between atomic time and the rotation of the earth. The leap second which was inserted at the end of June 1992 meant that the last minute of 30 June 1992 on the UTC scale was 61 seconds long. The adjustment is made just prior to 0 hours UTC which corresponds to 10 am Australian Eastern Standard Time on 1 July 1992.

It was the seventeenth positive leap second adjustment since the introduction of the present system of time scale co-ordination, using leap seconds, commenced in 1972. If the trend in the earth's speed of rotation changes in the future and increases, then the leap second adjustments required will be negative, ie; the last minute will be shortened to 59 seconds.

Maintaining a time scale which is synchronised with the rest of the world is very important to both Telecom and its customers and helps to ensure that services remain constant, reliable, and timely.

A 'Leap Second' is inserted into the atomic clock to maintain an approximate relationship between atomic time and the rotation of the earth around the Sun.

Electrical and optical measurements

A system of functioning and expanding standards emanates from TRL and is growing so that Telecom is able to provide a reliable and cost effective network service to its customers.

Successful operation of the Telecom network relies heavily on a vast range of sophisticated instruments that are used at the workface to establish, monitor, and repair the network. Measurements made with these instruments must be traceable to legally justifiable physical standards set by the National Measurement Act. Accordingly, a system of reference standards has been developed at TRL to support the calibration of such instruments.

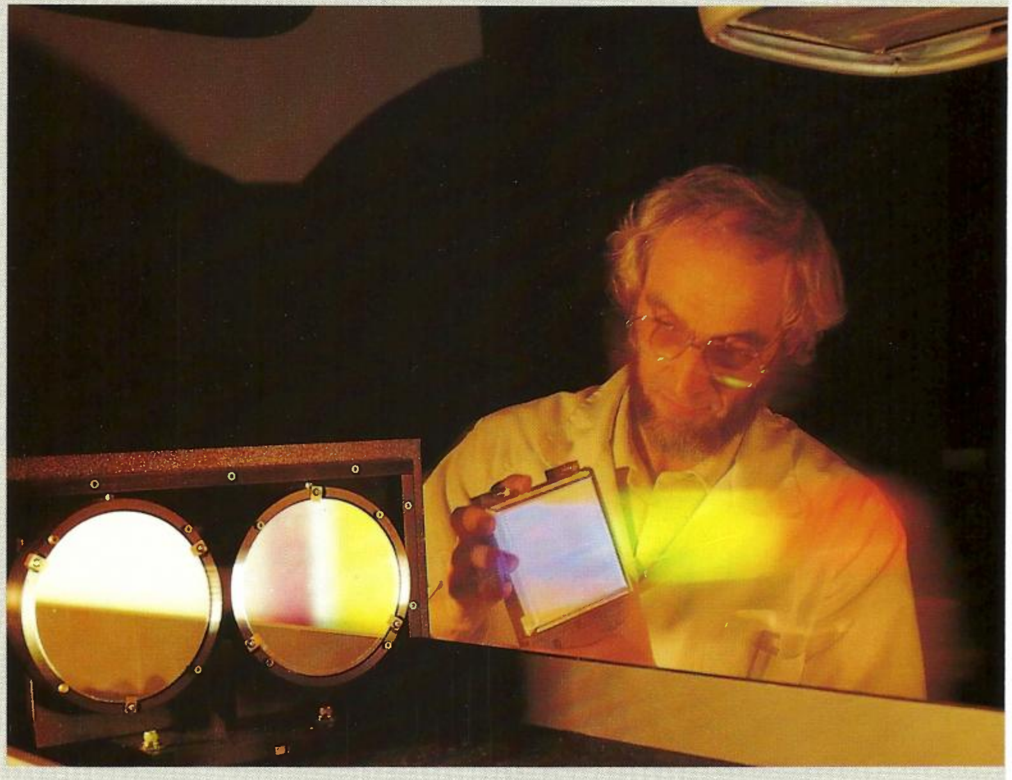
Telecom's standards are derived from the National Standards maintained by the National Measurement Laboratory, and suitably converted for the telecommunications field by TRL. They are then distributed throughout Telecom and its suppliers to give legally recognisable reference points for measurements. This hierarchy of traceability provides instrumentation that enables the network to operate to specification.

As telecommunications technology changes, it is necessary to convert the National Standards to form new reference standards to meet the expanding needs of the telecommunications field. Over time, the reference standards have evolved from dc through to microwaves. But with the rapid growth of optical fibre in the network, an urgent need arose to establish a new traceable measurement capability for optical quantities related to optical fibre performance. TRL developed a system of traceable optical standards now in service and functioning alongside the continually expanding system of electrical standards.

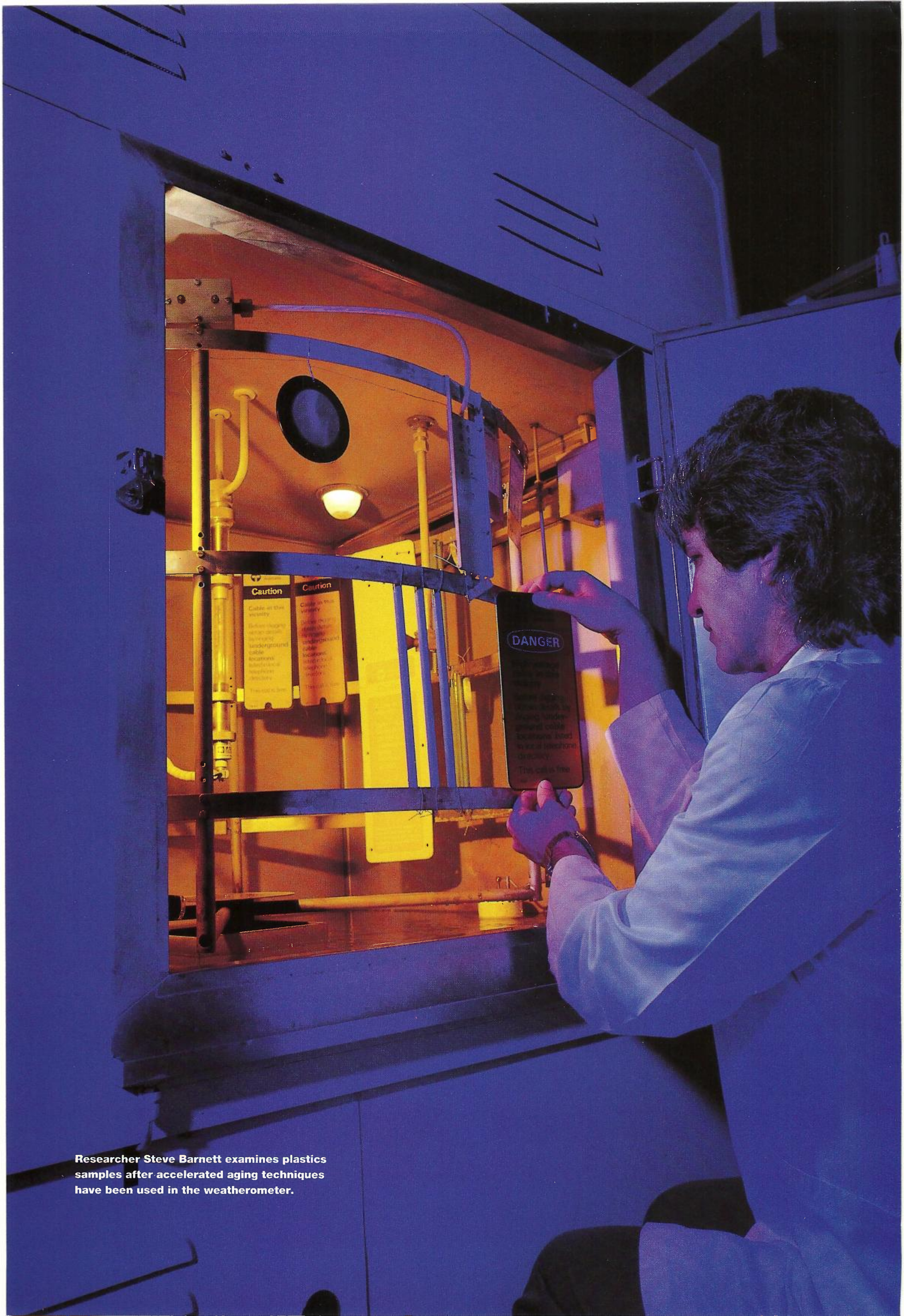
Some advances over the past year in the electrical and optical standards areas include:

- The calibration of more than 70 reference standards for Telecom and external organisation.
- Advances in calibration procedures for assessing optical source characteristics, and the development of associated computer controlled techniques.
- Taking a leading role in discussions on standards work, particularly about the progress of optical standards.
- Continuing advice to Telecom for establishing NATA (National Association of Testing Authorities) recognised calibration facilities for electrical and optical quantities.
- The successful application of automated procedures to DC inter comparisons and the transfer of these results to AC voltage and power measurements.
- Analysis of procedures using optical pulse methods, and the application of these for field and laboratory usage.
- Promotion, within Telecom, of the needs and conditions for traceability, as well as the evaluation of quality for laboratory performance.
- A continuing, deep involvement in the solution of a range of technical problems related to difficult and novel measurement situations.
- An investigation to upgrade the methods used for monitoring the environmental conditions in the TRL electrical and optical calibration laboratories.
- Development and nationwide circulation of a dual radio-frequency travelling standard for evaluation of Telecom's microwave power measurement facilities.

Considerable effort goes into evaluating the future reference measurements requirements of the Telecom network. From these evaluations, new techniques and references are being continually developed to satisfy Telecom's expanding customer needs.



(Above) In TRL's Optical Standards Laboratory, researcher Rodney Pyke examines a monochrometer's diffraction grating to measure the wavelength of light.



Researcher Steve Barnett examines plastics samples after accelerated aging techniques have been used in the weatherometer.

Polymers - Versatile & Pervasive; Improvement by Design

More efficient work practices and changes in polymer manufacturing technology, are providing Telecom with opportunities to be more flexible in design, manufacture, and installation of hardware. Expertise available at TRL ensures that polymer science and technology are closely matched to the field performance required from plastics materials.

Telecom Australia makes extensive use of polymers throughout its network. The success and reliability of those plastics for some applications depends on their ability to withstand harsh environments for periods of at least 20 years. The development, selection and specification of materials best suited to the service environment are key elements in providing a reliable network.

For over 30 years, low density polyethylene(LDPE) has been used as the sheathing material for external cables. Evolutionary changes to the formulation of the material have occurred over this period, but it is has always contained butyl rubber to resist environmental stress cracking, and carbon black for protection against ultra-violet radiation from sunlight.

With an excellent track record in the Australian network there has been no significant motivation to consider alternative materials, other than that the LDPE is manufactured using older, high pressure reactors. In recent times polymer manufacturers have developed more efficient low pressure reactors to produce a class of compounds known as linear low density polyethylene (LLDPE). In the longer term it is expected that these low pressure reactors will become the dominant manufacturing technology.

With this in mind, a few years ago TRL and local polymer suppliers commenced a programme to evaluate LLDPE as an alternative cable sheath for use in Australia. This research, which involved outdoor exposure of the LLDPE materials and laboratory tests, has now provided sufficient data and a significant level of confidence to revise Telecom's specification for external cable sheathing to incorporate LLDPE. Trial quantities of cable using LLDPE sheath are expected to find their way into the network during '92-93.

Another proven performer is polyamide-12(nylon-12), which has been used as a jacket over polyethylene cable sheath, to produce a cable which is resistant to attack from ants and termites. To resist degradation by the weather, heat and light stabilisers plus carbon black are incorporated into the polyamide-12.

The installation of optical fibre cables into metropolitan areas created difficulties for field staff in distinguishing between optical cables and metal cables. Given that the cable is buried during it's working life, and improved project scheduling means that cables are not stored outdoors for prolonged periods of time before installation, the concept of using a blue nylon jacket instead of black, gained acceptance. Co-operation between polymer suppliers, cable companies, and TRL enabled a laboratory evaluation programme to be completed with minimum delay and a specification developed for blue nylon jacket.

Another problem encountered by field staff is with cable installation in sandy soils. To assist cable installation in sandy soils, a commercially available pipe made from white high density polyethylene(HDPE) was proposed by field staff. This challenged the conservative approach of using weather-resistant black polyethylene for external applications. However, given changes in project scheduling, the concept was considered. TRL investigations revealed some inadequacies in the levels of heat and light stabilisers in the HDPE compound. These were rectified and together with other mechanical tests have enabled a specification to be developed for the plough-in, HDPE cable duct.

TRL is also researching the development of intrinsically conductive polymers, i.e. the molecular structure of the polymer enables the passage of an electric current through the polymer. For more than 100 years polymers have found significant use in the telecommunications industry on the basis of their electrical insulation and dielectric properties. Now, researchers around the world are establishing techniques for making intrinsically conductive polymers, and raising the question of how and when these materials might be applied to telecommunications.

Polymers with strong optical properties are also attracting increasing attention as the "photonics revolution" in telecommunications gathers pace.

The impact of polymers on Telecom Australia will continue to grow. Expertise available at TRL will ensure that the most reliable, cost effective, and successful polymer innovations are introduced to Telecom's network.

Standards of Time and Frequency

TRL provides Telecom Australia with time and frequency reference standards which form the basis of many customer services and are a vital element of network performance. Current development work is aimed at improving the quality of standards available and implementing remote calibration and verification for customer reference standards.

To meet a growing demand from computer system operators, Telecom has introduced a new time service from its Speaking Clocks which provides dial-up access to accurate time and date information in a computer readable ASCII format. A wide range of applications exist for this service; anything from automatic updating of master clock systems, to loading time into personal or mainframe computers.

TRL also offers technical consultancy to Telecom divisions and their customers on all aspects of network synchronisation, time and frequency related equipment, and system design.

Australia's Primary Standards of time and frequency are kept by the CSIRO's National Measurement Laboratory (NML). TRL is one of only two organisations within Australia authorised to operate Australian secondary standards of frequency and time interval which provides measurements traceable to the Australian Standards. TRL is also the only telecommunications Verifying Authority, which gives legal status for all measurements performed. Today's standards installation includes caesium beam frequency standards and equipment performing precise time transfer measurements with other Australian and overseas laboratories.

Distributions from the Time and Frequency Standard include:

- **Synchronisation of signals from the National Reference Clock.** This directly controls the clocks at every node of Telecom's digital networks for optimum performance. By synchronising its digital switching and transmission networks to this world standard reference clock, several important benefits are derived. These include, minimised digital slip performance with other national and international networks, and the capability to deliver sophisticated network facilities and features as part of the ISDN and synchronous digital hierarchy.
- **Precise frequency distribution throughout the analog network.** For example, the control and calibration of master oscillators in the trunk network. In addition, it provides standard frequencies for use as master clocks for timing, and in equipment service and calibration areas. Many of Telecom's customers in Government agencies and instru-mentalities utilise this distribution as a source of accurate frequency traceable to the Australian National Standard.
- **Provision of accurate and traceable time.** This is for the Speaking Clock network to the capital cities and many of the larger provincial cities, and distribution of the Civil Time Code signals transmitted in a binary coded decimal form over a voice channel. The Speaking Clock also provides the ABC and a number of commercial radio stations with timing signals which are broadcast as six pips to mark the hour.

ZAP SPLAT! Electrostatic Voltages on People

Researchers at TRL have been examining electrostatic voltage levels on people under various conditions, to assess the susceptibility of telecommunications equipment to electrostatic discharge (ESD).

Electrostatic charge is generated on a person from the contact and separation of two materials – typically their shoes and the floor. Once a charge has been generated, the decay rate depends on the available paths to equalise or earth the resulting voltage. Paths include any conductive or antistatic objects contacted, and the relative humidity of the air. When a charged person contacts or closely approaches a metallic object, the resultant rapid discharge causes radiated interference which can affect the operation of susceptible equipment. Similarly, a discharge directly into the equipment may cause damage or operational malfunction.

The growing use of low power digital circuits in products as diverse as telephones, modems and exchanges, has resulted in an increasing number of operational disruptions caused by ESD.

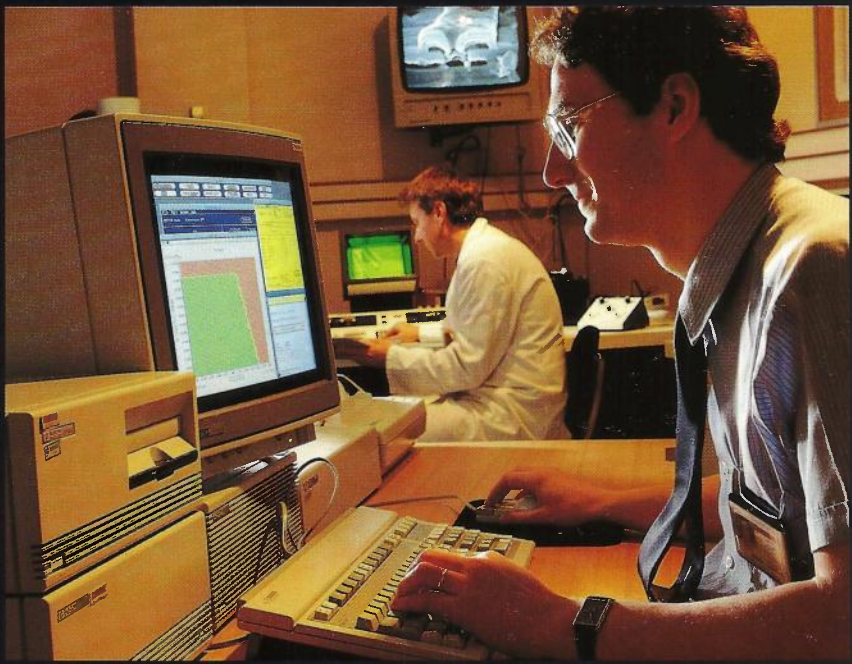
Equipment immunity to ESD can be controlled by the equipment manufacturer. However, the manufacturer must have an accurate knowledge of the characteristics of the ESD event, with regard to rise-time and peak amplitude of discharge current, and the spectrum of radiated interference. International research on this problem has shown that the factors which determine the robustness of equipment strongly depend on the voltage and peak current at the moment of discharge. ESD test generators, at various voltage levels, are used to assess the equipment. However, justification for the present testing levels is largely anecdotal because relatively little information is available on typical and worst case voltage levels generated by people at locations where telecommunications equipment is used.

Researchers at TRL are studying personal static voltage levels, and the interaction of clothing, flooring materials and furniture, in relation to humidity and situation. This work covers both locations where the ESD could be controlled, such as exchanges where antistatic flooring and humidity control can be used, and those locations where such control cannot usually be adopted, such as customer premises.

The work will contribute to developing more appropriate ESD tests, and to determining the most effective means of controlling ESD problems.

Researchers Steve Parkinson and David Willis are measuring the levels of static voltages generated by simulating the effects of a person walking on carpet in a low humidity in the Environmental Test Chambers.

VLSI Reliability Issues



Researchers Richard Thornton and Steve Molnar are using TRL's VLSI electron beam probe system to diagnose the cause of failure in an integrated circuit.

It is vital that researchers at TRL understand reliability issues associated with the cost saving use of Very Large Scale Integrated (VLSI) circuits to predict the overall reliability of telecommunications systems containing these components.

Apart from their increasing use in telecommunications equipment, VLSI circuits are also commonly used in many consumer products, from washing machines to computers. In many of these products, Application Specific Integrated circuits are being used to provide complex and sophisticated facilities at a cost which previously may have been prohibitive.

The complexity of VLSI circuits has increased significantly over the past decade. For example, memory storage capacity is increasing by a factor of four every three years. And the minimum size of the individual transistors which can be fabricated on a circuit has decreased from 4mm in 1976 to 0.5mm in 1992. With this increasing complexity, a number of reliability issues have emerged or re-emerged.

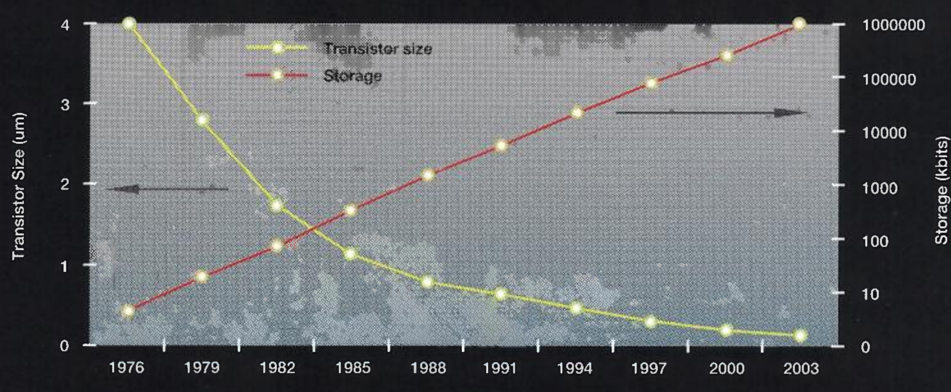
Problems arise from three main areas: First, as the size of the individual transistors is reduced, a number of mechanisms which result in progressive degradation of transistor characteristics have become more important. Transistors have also become more susceptible to damage by electrostatic discharge, and although protective circuitry is employed to help prevent such damage, it remains an area of concern. Additionally, the use of more complex, multi-layer metal structures has seen the re-emergence of a variety of metallisation problems, including electromigration.

Second, the need to adequately package relatively large circuits (up to 20 x 20mm) has necessitated the introduction of a variety of new package styles, with up to 560 pins being obtainable. However, there have been difficulties with some of the low cost plastic package types, particularly when combined with the rapid increases in temperature which occur during surface mount soldering operations.

Third, is the need to provide adequate thermal management. Although not an issue for all devices and applications, it is desirable to keep the temperature of a working device as low as practicable because of the numerous failure mechanisms which are accelerated by operation at high temperature. Large circuits, running at high speeds can dissipate substantial power, and in some cases, the provision of adequate heat removal is critical to achieve the desired reliability.

Before taking any cost saving new integrated circuit technologies on board, experts at TRL examine for defects which may indicate poor reliability. This ensures that Telecom makes no mistake with the installation of new and technologically advanced equipment.

Feature Size and Storage Capacity of Dynamic RAM



Improving the Workplace

TRL has been involved in a series of assessment programmes to assist the National Health, Safety and Environment Branch of Telecom. Experimental work carried out by TRL provides data which enables Telecom's occupational hygienists to evaluate work practices and formulate policies on a national basis.

Portable, Combustible Gas Detectors

Telecom field staff who work in manholes and pits within the external plant network use portable, combustible gas detectors prior to entering work spaces. TRL has been evaluating the use of new gas detector technology that is lighter, more compact, and easier to operate than those previously issued to staff. Extensive tests have enabled TRL to make recommendations concerning the best instruments available to meet Telecom's requirements.

The experimental variables, under which accuracy of detector response is measured, include; an extended operational temperature range of 10°C to 40°C; a series of relative humidities ranging from 0% to 93%; and an ability to detect various concentrations of gases below the Lower Explosive Limit. Performance of the detectors in the presence of potential interfering gases at various concentrations is also assessed.

Exposure to Dust Particles

TRL in co-operation with TNE Metro in Western Australia, has carried out a series of measurements to assess worker exposure to dust. Drilling of the national optical fibre cable network installation programme is performed in a great variety of soil types, with various digging and ploughing processes. Several of these have the potential for worker exposure to both inspirable and respirable dust fractions. Depending upon particle size, dusts entering the respiratory system lodge in different areas of the lung. Inspirable dusts have diameters up to 100μm, and can deposit in the upper lung areas. Particles with diameters less than 5μm are termed respirable and settle in the gas exchange areas of the lung.

Exposure measurements were taken for external plant operators during their typical work shift. As a result, modifications to some plant equipment air-conditioning filtration systems are being implemented and trialed to reduce worker exposure. Further monitoring is

Modifications to some plant equipment air-conditioning filtration systems are being trialed to help reduce worker exposure to dust.

planned in both country and urban areas to gather more data and to make recommendations relating to worker dust exposure.

Exposure to Plastics Fumes

Extensive data collected by TRL confirmed that under normal works practice, Telecom staff are not exposed to hazardous products when using thermo-shrinkable plastics tubing for cable jointing. TRL collected data from the field, training schools, and laboratory simulations. The new data sets were processed statistically on commercially available "compliance" software, and showed that Telecom workers were not at risk.

Exposure to dust particles during the drilling of the national optical fibre cable network.

Laser Reliability Studies

TRL has been working on ways to improve Telecom's Inter Exchange (IEN) and Customer Access (CAN) Networks which could provide customers with faster and more powerful network capabilities at a minimum cost. Nevertheless, the most important part of this research is to make sure reliability is maintained.

Semiconductor lasers are crucially important to Telecom's IEN and CAN. After many years of development, semiconductor lasers currently in use in the main trunk networks have proven to be reliable. However, these lasers are expensive, rely on a relatively old technology based on lattice matched materials, and only output a few milliwatts at most.

State-of-the-art lasers for telecommunications applications are aimed at reducing line width, improving threshold currents, increasing modulation speed, increasing power, and reducing cost. One way of achieving some of these goals is to introduce strain into the active layer which removes the degeneracy of the light and heavy hole bands. This results in better threshold currents and light characteristics.

In the case of pump lasers for erbium doped fibre amplifiers (EDFA), strain allows laser operation at 980 nm – the ideal pumping wavelength. Even for small lattice mismatch, the stresses involved are in the order of tonnes per square centimetre. Such stresses cause concern for the reliability of the devices.

Because of network demands, Telecom would like to deploy devices such as EDFAs in the near future without the long testing times normally associated with a critical technology. As part of an alternative methodology for assessing the reliability of these devices, the Photonics Section is undertaking an indepth investigation of the physical mechanisms for strained layer laser degradation. The goal is to find key physical parameters, to be used in conjunction with reduced lifetime testing, to predict the reliability of strained layer structures.

Current work is focused on the lifetime of laser diodes that work at 980 nm, emitting powers in the order of 100 mW for use in EDFAs. The high operating powers, the 20 year lifetime that Telecom requires from its plant, and the urgent requirement for EDFAs in the network makes these structures particularly important. Experimental work is being carried out in collaboration with the University of Sydney under a contract with Telecom to further our understanding of the main degradation mechanisms of laser diodes. Some of the experimental work includes the influence of strain, optical power density, and the role of indium in dislocation movement.

New telecommunication technology cannot just be a quick fix for an improved network. First, TRL must thoroughly put it to the test because the installation costs often require that the technology not only must perform well, but that it performs well for 20 years or more.

Payphone Reliability – A Case of Continuing Improvement

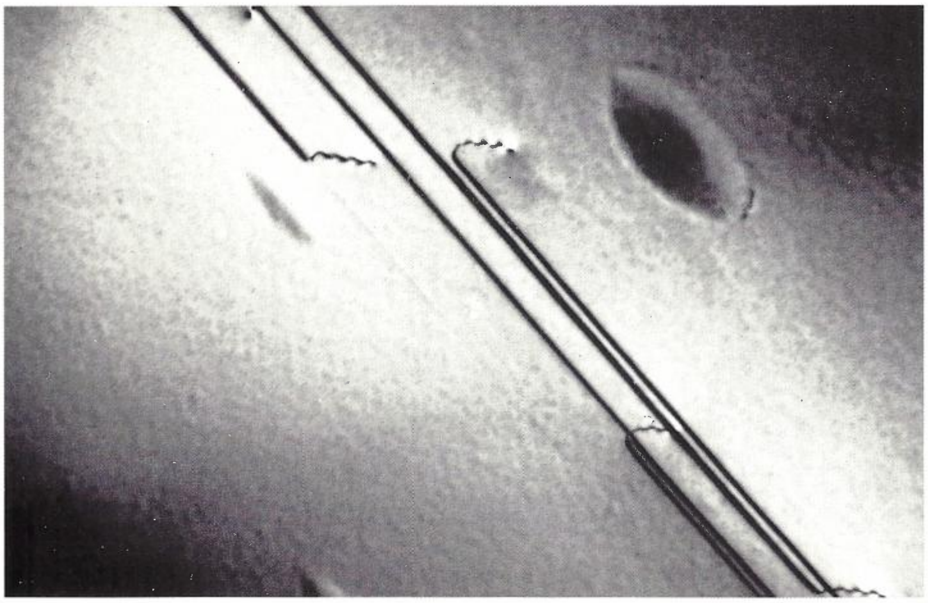
TRL has made several contributions to assist Telecom Payphones Services with the design of payphone cabinets that must be robust enough to perform reliable technical functions, and have good aesthetic qualities because of high public expectations.

Payphone cabinets use plastics materials for many applications including surface coatings, mouldings and adhesives. Ongoing improvements in reliability and performance are being made through the use of better materials that are tested at TRL.

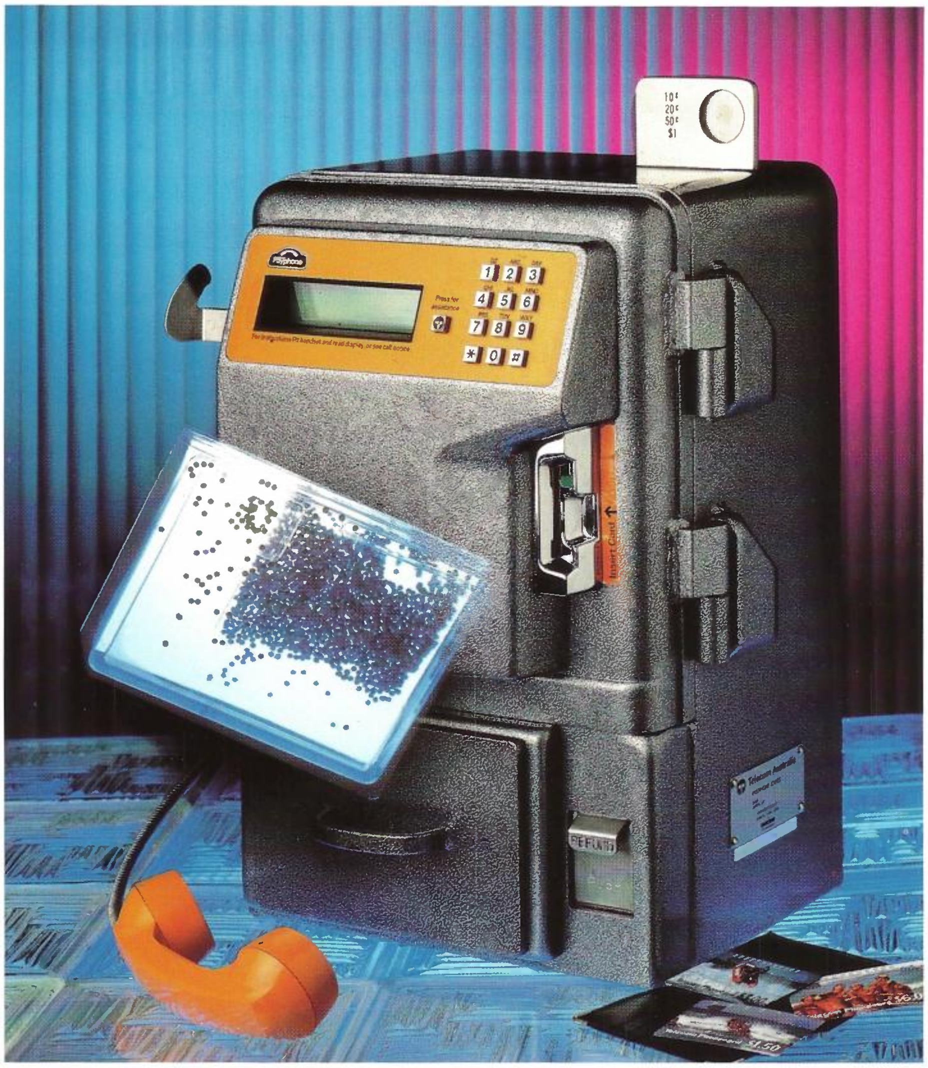
Telecom-Gold Plastic Dome Roof

The Telecom-Gold plastic dome roof used on some cabinets is a good example of where the design, choice of materials and production procedures are affected by technical and aesthetic requirements. The domes are manufactured from a weather-resistant polycarbonate. TRL examined a competitive material that uses different technology to achieve weather-resistance. The two materials were shown to be perform similarly. Approval for this alternative material now allows greater economic and supply choices.

The flammability aspects of these different materials were also considered and found to be satisfactory for the application. The high visual profile of the painted roofs is important, partic-



State-of-the-art lasers for telecommunications applications must combine reliability with reduced line width, improved threshold currents, increased modulation speed, increased power, and reduced cost.



TRL's tests revealed that a PVC box to collect punched-out phonecards would cause potential field problems with the build up of static electricity.

ularly at night, so the light transmission must be uniform. A careful examination of the methodology for assessing the light transmission properties showed that the proposed specification was more than satisfactory. Thus allowing all manufacturers to reliably produce similar roofs.

Powder Coated Metal Mesh

The metal mesh used on the lower half of full-length payphone cabinets is often covered with a Telecom-Gold coloured powder coating. TRL used accelerated weathering techniques to investigate the longevity and colour fastness of an imported coating and found them to be inadequate. In this case the currently used and locally produced materials were found to be the best available. Further developments by the off-shore company may provide an additional satisfactory alternative.

Phonecard Punch

Within the payphone itself, a small replaceable plastics box was proposed to collect the punched-out portion of the phonecards. The box was suspected of being subject to static problems that would result in a blockage to its small entrance. Of the alternative materials, TRL experiments showed that the amorphous poly(ethylene terephthalate) box was far less subject to this problem than the PVC box. Importantly, the recommendation was made prior to the first use of the box and hence potential field problems were averted.

Whilst these and other investigations are not major developments on an individual basis, they interact synergistically with each other to produce continuing improvement of payphone reliability and performance.

The Telecom Gold plastic dome roof and the powder coated metal mesh used on the lower half of payphone cabinets demonstrates the importance of aesthetics and reliable design.

The growth in sophistication and extent of Customer Premises Networks which began in the '80s, will continue to have significant impact on public networks in the '90s and beyond.

TRANSMISSION NETWORKS AND STANDARDS

The Transmission Network Services branch of TRL is meeting changing customer needs in the most effective way by working to achieve optimum use of copper pairs, optical fibres, and radio technology. Due account is also taken of the electromagnetic immunity and susceptibility of network, plant, and equipment to maintain utmost safety and reliability.

The growth in sophistication and extent of Customer Premises Networks (CPNs), which began in the '80s, will continue to have significant impact on public networks in the '90s and beyond.

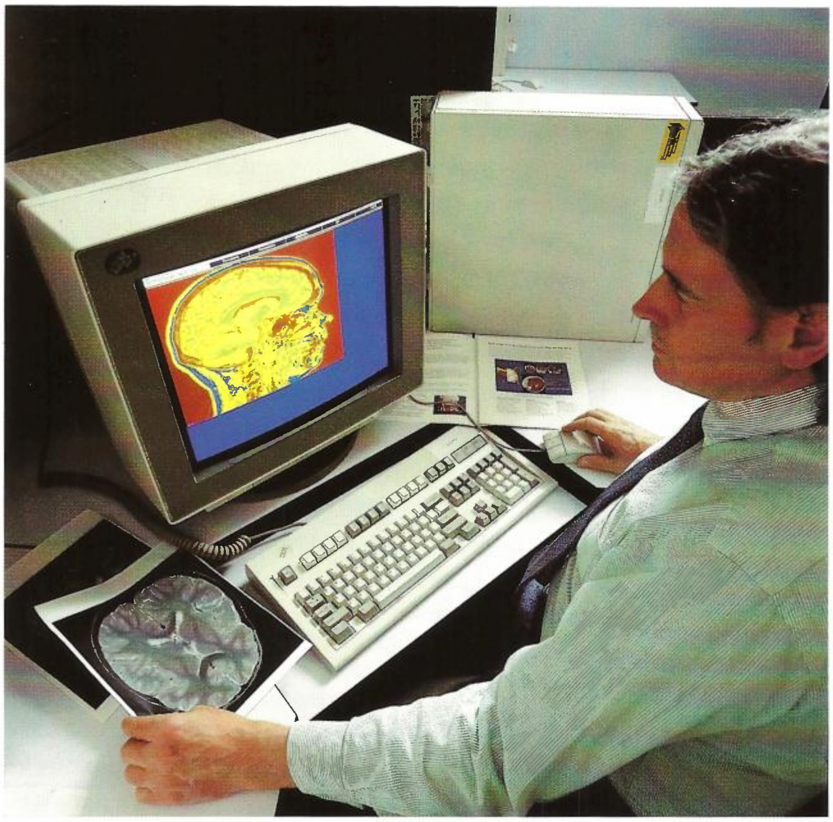
Customers who use telecommunications as an integral part of their business, have used Local Area Networks (LANs) and the like to build CPNs with sophisticated capabilities which meet their needs at one or more of their premises. Now, they want such capabilities to be extended between their own premises and that of their customers or suppliers. These customers in particular, see the public network only as a means to interconnect their premises. So, public network services and the capabilities of the public network transmission platform must match and respond to the interconnection and performance requirements of CPNs.

Developments in CPNs will be driven by a variety of forces, such as multimedia applications with integration of voice, data and video with high resolution graphics, pay television and mobility. These developments will directly influence the public Customer Access Network – the network between the customer and the local exchange.

In contrast to the Customer Access Network, the Inter-exchange Network is not so much affected by the particular technologies used in CPNs, because of traffic concentration at the local exchange. Optical fibre with optical amplifiers will be the dominant technology to manage the ever increasing capacities required from the Inter-exchange Network . Furthermore, network synchronisation performance will need to meet the increasing demands of new multimedia network services.

The following chapter will provide a more in-depth look at some of the technologies of future networks that will support the introduction of more sophisticated and more powerful telecommunications services.

Researchers, Barry Gilbert and Doug Farr adjusting and assembling a High Resolution Antenna at Telecom's Caldermeade Antenna Test Range.



Kevin Morris from the Australian Computing and communications Institute demonstrates the type of medical imaging application that will be made possible via Telecom's high speed Customer Premises Networks. Complex images such as this cut-away three dimensional view of the brain will be sent across the country via Telecom's networks at a billion bits per second or more.

High Speed Customer Premises Networks

TRL is investigating future high speed Customer Premises Networks (CPN)s, such as Gbit/s Local Area Networks (LAN)s, to be in a position to advise Telecom on the impact of interconnection via the public network. Simulation studies of various candidate protocols are being undertaken to ensure that performance and reliability issues are addressed in the development of an interconnection strategy, while maintaining an appropriate grade of service for customer applications.

Future communication requirements for distributed processing and storage, data integration, voice, video and graphics for multimedia applications, will increase the need for high speed LANs. Transmission capacities beyond 1 Gbit/s will enable the development of applications such as medical imaging, multimedia conferencing, computer animation and computer visualisation. A medical image could be transmitted in less than 1/10 of a second so that it could be remotely examined by an expert – long distance instructions could potentially save lives.

Visualisation applications would require image rates up to about 25 images per second, where the images could be high resolution full colour, thus necessitating transmission rates up to 600 Mbit/s. Although these applications require large bandwidths, there are many areas where visualisation is seen as the ideal approach to analysing a problem. The combination of human eyes and brain is still the best process or of information for a great many tasks. For example, a computer may be used to generate 3D maps from satellite and aerial images, but only the experienced human operator can pick up telltale signs of areas which might prove worthy of further exploration.

The first implementations of these Gbit/s networks will be in the CPN, where customers will install high speed networks in-house for the required applications at a single site. Following this will be demands for applications to be available to remote users and for the interconnection of these networks at different sites. At this stage, the public network will be required to interconnect high speed CPNs while maintaining performance for the customer.

The CPN is a driving force for the development of the public network. To efficiently interconnect high speed CPNs through the public network, TRL has been studying CPNs to determine the critical factors of their operation and the requirements of the applications.

The Cyclic-Reservation Multiple-Access (CRMA) protocol has been proposed recently by research scientists at IBM as an access scheme for such high speed networks. TRL has simulated the protocol to investigate the throughput performance and the characteristics of the access delay (the time elapsed from the instant that a packet is ready to be transmitted at a station until it is transmitted onto the bus).

Results show that there is a position dependency of the access delays observed by each station due to the intra-cycle delay and the propagation delay between that station and headend. The intra-cycle delay is the time interval between the arrival instant of the first slot of the cycle to a station, and the arrival instant of the slot in which the first segment of the packet is placed by the station. Stations closest to the headend where the cycles are generated use the first slots in the cycle, thus having the smallest intra-cycle delays. Stations farthest from the headend must wait for the slots used by the previous stations to pass before they can use the remaining empty slots in the cycle. At low load level, intra-cycle delay is much smaller than the propagation delay. When the load level is high, the back pressure mechanism decreases the reserve command generation rate and increases the length of cycles. This results in longer intra-cycle delays comparable to propagation delay for the downstream stations.

The simulation results also show that under heavy traffic conditions, (greater than70% load), coming from a few stations, the back pressure mechanism increases the access delays observed by the heavily loaded stations in proportion to their load. At the same time, the access delays observed by the normal-load stations are not significantly increased by the extra loading.

The throughput of each station under sustained overload is observed to be independent of its position on the network. The protocol provides throughput fairness independent of network size, due to its cyclic nature.

CRMA can be used for Gbit/s LANs. However, TRL will carry out further studies and detailed comparisons with other protocols such as DQDB to determine the most appropriate protocol for this type of network. The choice of high speed CPN and its applications will have an impact on the developments of the public network, with respect to the performance required, to ensure satisfactory operation of applications over wide areas utilising public network facilities.

Reducing Electromagnetic Interference (EMI) Emissions from Digital Telephone Terminals

TRL must be flexible and practical enough to cater for Telecom's wide range of customers who often have needs which extend beyond the usual. Recently, TRL provided a solution for the Department of Defence (Navy) that meets stringent military electromagnetic interference (EMI) emission standards whilst maintaining a very competitive price.

The telecommunications solution for the Department of Defence revolved around the installation of a Telecom 9600L Private Automatic Branch Exchange (PABX), a number of analog and digital ET-IV terminals, and other assorted terminal equipment. The Department of Defence asked Telecom to provide a report of measurements of the electromagnetic emission levels from the proposed system. Measurements were performed in accordance with U.S. military standards, and results showed that emission levels were as much as 50 dB above the limits. The ET-IV digital terminal was one of the worst offenders.

The Department of Defence commissioned Telecom to devise methods of reducing emissions from ET-IV terminals to levels near or below the military standards limits. The retrofix solution had to be inexpensive in comparison to the cost of the basic unit, and had to maintain the unit's appearance and functional performance.

Internally, the ET-IV terminal consists of two printed circuit boards. The smaller of the two circuit boards is a DC-DC converter which feeds power to the main electronics and communications circuit board. Measurement of the frequency spectra revealed two large single frequency emissions – the source of which was the DC-DC converter. These emissions were up to 50 dB above military standards limits. The two single frequency emissions were completely eliminated by applying shielding and filtering techniques. The remaining emissions from the ET-IV were due almost entirely to sources present on the main printed circuit board and were up to 35 dB above military standards limits.

TRL devised a method whereby interference currents and voltages generated on the main printed circuit board were prevented from exciting the balanced telephone pair cable or the handset cord of the ET-IV terminal. It is essential to prevent interference currents flowing on the balanced pair cable because even a short length of cable will provide a highly effective radiating system in comparison to direct radiation from a printed circuit board.

TRL incorporated a ground reference system into the ET-IV terminal. Researchers used a low shunt impedance to provide a path back to the reference system for antenna mode signals on the telephone pair cable. The telephone pair cable was effectively eliminated from the radiating system. The electric field emissions in the range 15 kHz to 30 MHz were reduced to levels near to or below military standards limits. TRL has achieved further reductions in the range 30MHz to 1000 MHz by inserting a high frequency choke into the handset wiring.

All modifications to the ET-IV are incorporated within the terminal thereby maintaining its original appearance. The success of the modifications means that Telecom can provide the Department of Defence (Navy) with modified ET-IV terminals that meet stringent military standards of electromagnetic emission specifications, at a highly competitive price.

Researcher Steve Iskra measures EMI radiated emissions from a digital ET-IV terminal to ensure that it meets U.S. Military Standards EMI requirements.

Antenna Calibrations for EMI Measurements

An antenna test site developed by TRL in the Dandenong Ranges in Victoria has allowed researchers to take precise measurements of the receiving characteristics of EMI measuring antennas. The calibrations have provided the antenna factors (AF) required for highly accurate Electromagnetic Interference (EMI) measurements, which are intended to ensure the interference-free reception of radio and TV services.

Information technology equipment (ITE) intended for connection to the public switched telephone network (PSTN) in Australia must meet the EMI requirements of Australian Standard AS3548-1988, which is identical with the International EMI Standard CISPR Publication 22. These Standards require that the electromagnetic disturbances radiated by ITE in the frequency range 30 MHz to 1000 MHz are measured so that they do not exceed limits laid down in the Standards.

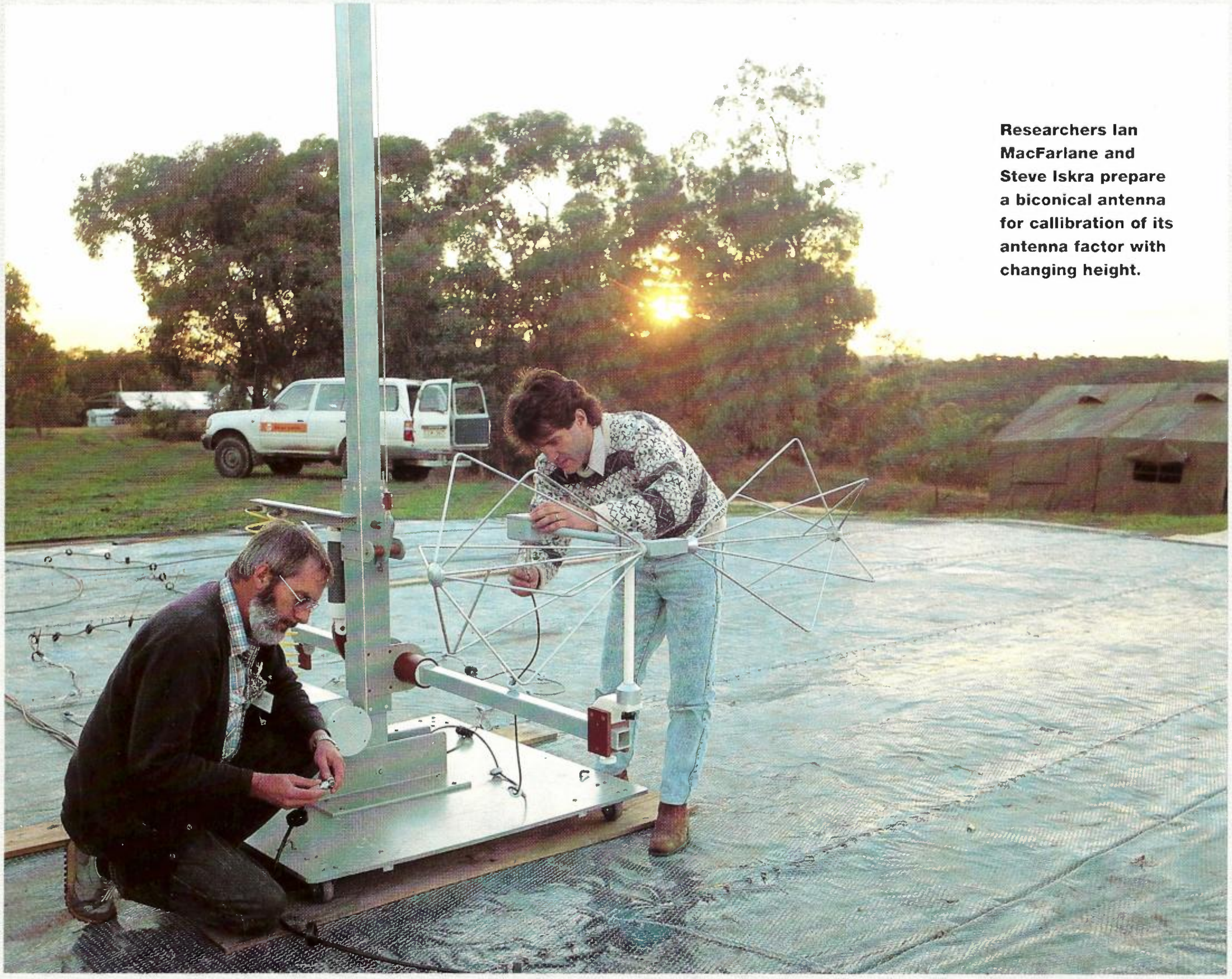
In general, it is necessary to measure the emitted disturbances on a standardised radiation measuring site. The measurement antennas, placed at a horizontal distance of either 10 metres or 30 metres from the equipment to be tested, are height scanned between 1 and 4 metres above the ground to detect maximum strength of the radiated electromagnetic fields.

To make accurate measurements of the radiated fields, researchers at TRL must have an accurate knowledge of the response of the measuring antennas to the fields incident upon them. This is obtained by accurately calibrating the AF; the AF directly relates the field strength incident on an antenna to the resulting voltage that the antenna supplies to an accurate measuring receiver.

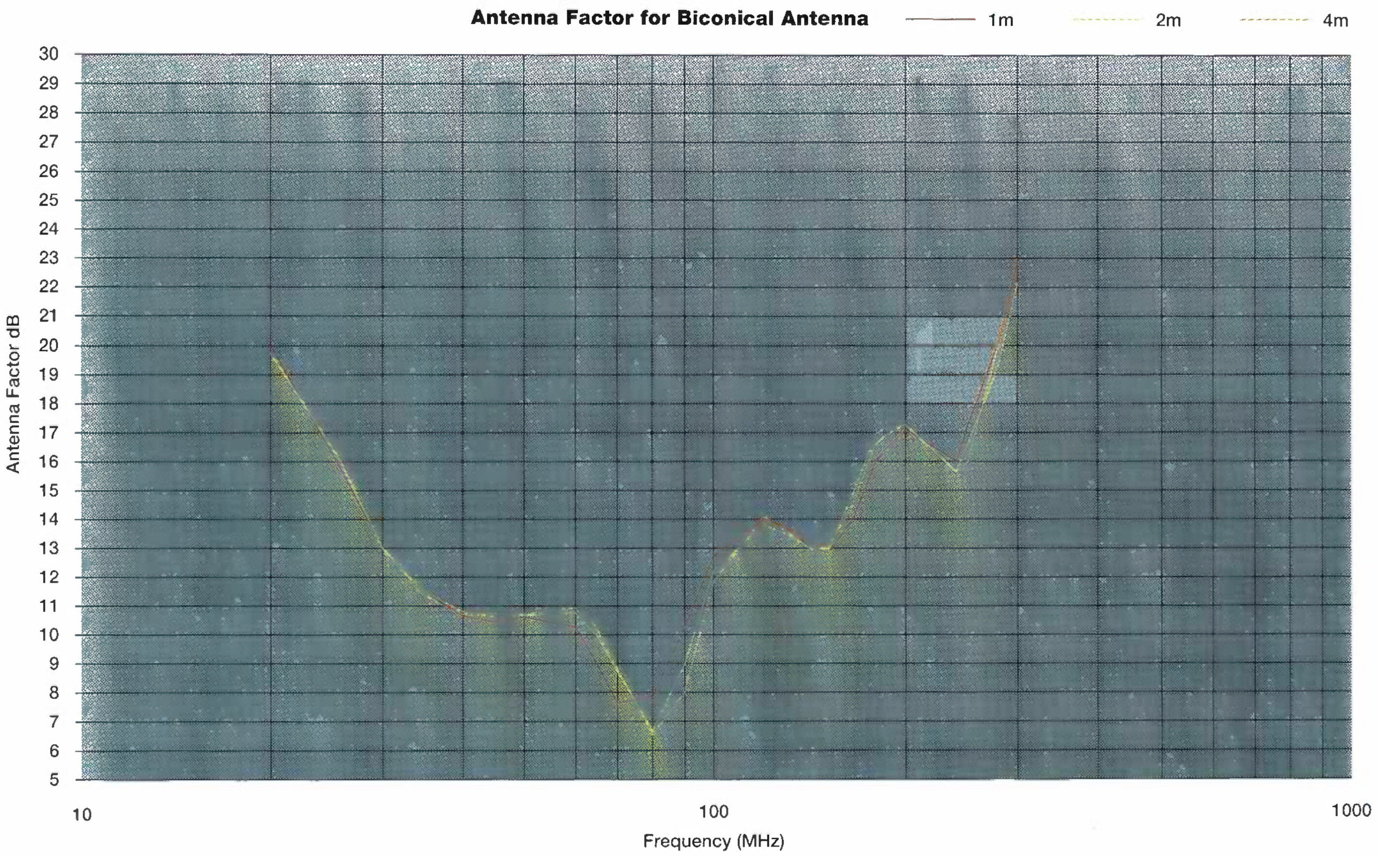
Standardised radiation measuring sites known as Open Area Test Sites (OATS) incorporate a metallic (highly reflecting) ground reference plane. For accurate field strength measurements, it is necessary to determine the influence on the AF of close proximity of the antenna to a metal ground plane at heights of 1 to 4 metres. The AF will also include the effects on antenna response of antenna impedance changes resulting from mutual coupling of the antenna to its image in the ground plane – particularly at frequencies near antenna resonance. This is most important for antennas in the form of tuned or half-wave dipoles, and for broadband antennas at frequencies near the resonant and anti-resonant frequencies of the antenna arms.

A good quality OATS equipped with a large metal ground plane can be used to calibrate AF with changing height. A good OATS can also be described as one having a near-ideal smooth reflecting ground plane of large extent, with no significant obstructions or reflecting objects in its vicinity.

TRL has devised a method of AF calibration over a range of heights, and a number of EMI measuring antennas have been calibrated on a temporary near-ideal OATS. A large privately owned clearing in the Dandenong Ranges was levelled and a fine mesh of galvanised wire was laid out covering an area of 27 metres by 20 metres to form a flat, perfectly reflecting ground plane. TRL explored the electromagnetic characteristics of the OATS over a period of several months. Problems of unwanted



Researchers Ian MacFarlane and Steve Iskra prepare a biconical antenna for callibration of its antenna factor with changing height.



Antenna factors of a typical broadband biconical antenna, showing changes with height caused by the influence of antenna coupling to its image in the ground plane.

reflections, and scattering of the electromagnetic fields used for antenna calibration, were identified and eliminated or minimised. The antenna factors of a range of tuned dipoles and broad-band antennas were determined at a number of heights from 1 to 4 metres above the ground plane in the frequency range from 20 MHz to 1000 MHz.

After accounting for all the identifiable uncertainties involved in the AF calibrations, researchers at TRL determined the measured antenna factors with a total absolute uncertainty of less than +0.75 dB for antennas at the height of 1 metre; and less than +1.25 dB at other heights up to 4 metres.

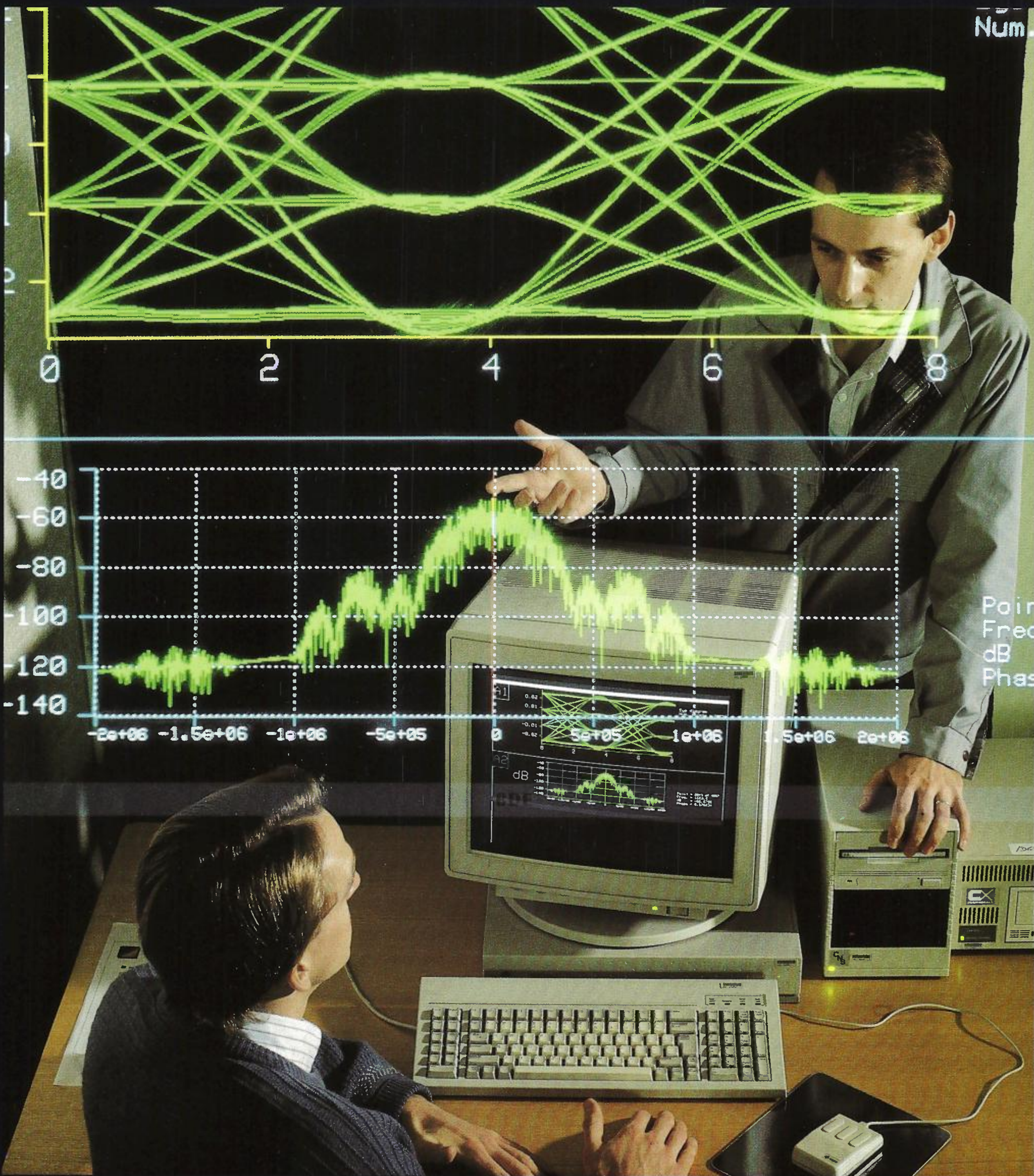
The calibrations have provided the antenna factors required for highly accurate EMI measurements and have demonstrated very clearly how the antenna factors are influenced by height above a ground plane.

High Speed Digital Transmission Over Copper Pairs

TRL, in collaboration with the Telecom Access Product Group, has commenced investigations on new digital transmission systems capable of delivering megabit rate services to customers over conventional copper pairs. These are the High Rate Digital Subscriber Line (HDSL), the Asymmetric Digital Subscriber Line (ADSL) systems (which are being developed overseas), and Very High Rate Digital Subscriber Line (VHDSL) systems which are at the concept stage.

Simulations at TRL will help predict the performance of emerging overseas system designs, under the constraints of loop topologies and crosstalk and impulsive noise levels characteristic of the Australian network. Equipment testing will follow, as prototypes become available.

The HDSL systems are intended primarily for business applications, such as primary rate ISDN, that require the same high bit rate (typically 784 kBit/s to 2.0 MBit/s) in both directions. Whereas ADSL systems are being designed for rapid information access applications, including distance education, and video based shopping and entertainment services, where the high bit rate (typically 1.5MBit/s) is only required to be carried down line to the customer. These latter systems incorporate a lower bit rate control channel to carry the customers instructions back to the information source.



Researchers Scott Yeomans and Tony Guy simulate HDSL digital transmission for cost effective provisioning of enhanced network services over existing copper pairs.

Both HDSL and ADSL systems are designed to operate over exchange lines of 3-6 km in order to reach the vast majority of customers. VHDSL systems are intended to carry higher rates (4-12 MBit/s) over shorter distances in the order of 1 km or less. They will be used on copper pairs linking customer premises to a neighourhood fibre-fed cabinet or piller. The need for all three system types is expected to exist over the next 10 to 15 years before fibre-to-the-home systems become ubiquitous.

Much of the impetus driving the development of these new systems stems from the high costs and lengthy times currently required to provide megabit rate pair cable customer services. For example, the work of pair selection, bridge tap removal, repeater installation and loop testing, can in some cases take months. In comparison HDSL and ADSL transceivers will adapt to the line without the need for such special engineering. Consequently, their provisioning will be much simpler; essentially akin to that which presently applies to the Plain Old Telephone Service.

These investigations of high speed data transmission over the existing copper network will mean that Telecom's customers have cost effective access to future services before optical fibre is ultimately installed to the home.

Optical Fibre Developments in the Customer Access Network

Cost still remains the main stumbling block to the wide scale use of optical fibre in the Customer Access Network (CAN) – particularly for residential and small business customers. Recognition of the need to minimise the costs associated with the use of optical fibre in this part of the telecommunications network led to TRL's pioneering work on the use of Passive Optical Networks (PON). These networks have the inherent advantage of reducing the amount of fibre and opto-electronics required to provide optical access to a cluster of customers.

A PON involves a double star topology whereby a single optical fibre is installed between the local exchange and a passive multi-port optical coupler located near the cluster of customers. The optical coupler acts as a splitting/ combining element for the optical signals transmitted over the network.

TRL's work involved the development of a prototype TDMA digital mobile telephone system known as MACNET. The experience gained from this system gave Telecom the confidence to undertake a major fibre-to-the-customer-premises (FTTCP) field trial based on the PON technology. The contract for the development of the equipment for the field trial was won by NEC Australia and signed in February 1992. The trial examines both fibre-to-the-home (FTTH) and fibre-to-the-curb (FTTC) equipment for the delivery of a combination of POTS, ISDN, 2 Mbit/s, and distributive video services.

With FTTC, the fibre does not extend all the way into the customers premises but rather terminates in remote nodes installed on the curb. The existing copper pair distribution/lead-in cable is used from these nodes to the customer premises. The opto-electronic devices at each node are shared by the customers (typically 4 or 8) connected to that point. This part-way step to FTTH access is thought to provide cost savings in the near term, and hence an economically viable compromise that may allow the use of fibre in the CAN in an earlier time frame than would be possible for FTTH.

Although fibre access is not expected to be cost competitive with copper pairs for the delivery of narrow band services until the later part of the 1990s, it is cost effective for the delivery of wide bandwidth services to large business and corporate customers. For example, in January 1992 Telecom introduced a commercial service known as "Lasercast", which involves the fibre delivery of sub-carrier multiplexed video channels to business customers. An initial customer base of 4 and 5 star hotels in Sydney is receiving tourist information from a service provider, who is distributing his program material over the Telecom provided distribution

Telecom Australia's launch of 'Laser Link' (the umbrella name for linking business and residential customers to the national optical fibre network) was held in Melbourne at the Hotel Como. The Channel Ten Network's 'Good Morning Australia' team, linked via Telecom's optical fibre network, were on location to show their viewers what the 'home of the future' will look like. Researchers from TRL were at the launch to help connect and set up these future services that will be available to Telecom customers.

network, to minimise costs associated with video transmission equipment.

TRL has played an important role in the establishment of the Lasercast network. Researchers at TRL have derived a performance model that allows the maximum number of video channels to be delivered over a given distance, and PON split size for a specified minimum video signal-to-noise ratio performance. TRL also performed the initial acceptance tests on the commercial video equipment purchased for the network and provided assistance with the installation and testing of a number of video links set up to demonstrate the Lasercast service to prospective customers. Measurements made on these links were used to verify the predicted performance based on the theoretical model developed by TRL.

To prepare for the anticipated future demand for fibre access, Telecom has undertaken a fibre installation program that will provide a fibre access capability to 60% of customers by 1994/95. This "Laserlink" program was successfully launched by Telecom in February 1992. It demonstrated the types of services that will be delivered over optical fibre to a "Home of the Future". These included home shopping, interactive learning, home office applications, Pay-TV, and access to video libraries and high quality CD audio services.

TRL was active in planning and establishing optical fibre based displays used during the launch. Researchers devised the access arrangement used to provide the simulated services, and assembled the optical equipment used to deliver the services from the television operating centre and a hotel apartment unit used for the launch. Researchers were also on hand during the launch to answer technical questions from the media representatives and general public. Contributions to the success of the Laserlink launch drew on TRL's considerable experience and expertise in optical transmission technology, its "hands on" experience with "off-the-shelf" fibre optic video systems, and its ongoing research related to the transmission of video signals over PONs.

Ongoing research relating to the use of optical fibre for customer access includes a comprehensive study of the local and network options for powering the opto-electronics in the customer terminal unit. The basic telephone service is currently powered from the network and continues to operate when local mains power failure occurs. With optical access, mains power backup is required to provide a comparable grade of service. The outcome of the studies will impact on the take up rate for fibre access. Future developments of "smart homes" that require continuous power, and other services such as smoke detectors and alarms, will require the development of battery backup systems that may also be used to provide backup power to the optical terminal equipment with fibre access.

A phased introduction of fibre will target corporate, large business, small business and then residential customers. PON systems designed to provide fibre access to the "building" or "office" may precede the cost effective use of FTTC or FTTH systems.

The information obtained from the FTTCP trial, and other overseas fibre-in-the-loop trials, together with the ongoing TRL research, will help Telecom plan for the most appropriate and cost effective applications for optical fibre in the CAN network.

Radio Access in the Customer Access Network & Personal Communications Services

Researchers at TRL have been actively investigating several aspects of radio access in the Customer Access Network (CAN), and Personal Communications Services (PCS). The popularity of analog cellular and cordless telephones world-wide has resulted in the development of several new high capacity digital mobile

Researcher Adrian Martinus is conducting CAN propagation measurements at a suburban site in Tecoma in the Dandenong Ranges National Park in Victoria.

radio standards such as CT2, DECT, GSM and CDMA to meet the expected demand in the '90s with advanced services. At the same time, new applications for these technologies are being proposed. These include wireless PABX, radio LANs, and now, radio access in the CAN and PCS.

For radio access in the CAN, radio links will be established between transceivers attached to the external walls (or roofs) of customer premises and radio base stations. Premises wiring would be used to connect the transceivers to a fixed terminal or to a domestic cordless system.

Radio access in the CAN provides the potential for a reduction in CAN costs and service delivery time – especially for temporary installations such as exhibitions and carnivals, where a cable solution is impractical, and for service provision in difficult terrain.

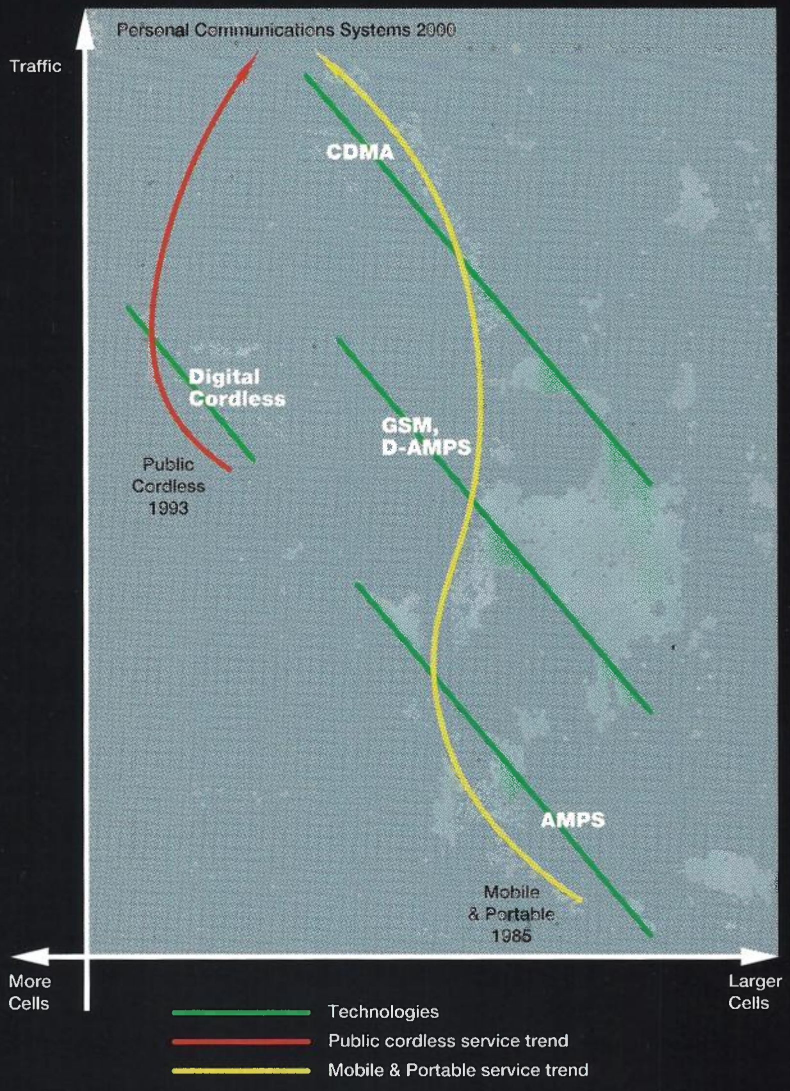
The aim of PCS, on the other hand, is to enable high quality person to person communications independent of location by providing access to mass market pocketable terminals.

TRL's research includes service definition, channel characterisation, radio network architecture, terminal powering, performance analysis, and assessment of potential technologies and cost considerations. The radio channel for the CAN and PCS environment has been extensively characterised by conducting propagation experiments at several sites, both indoors and outdoors. This involved the measurement and collection of channel impulse responses from in and around suburban dwellings, suburban offices and high rise buildings in the central business district (CBD).

The collected data has been analysed to obtain the statistics of important design parameters, including path loss, multipath delay spread, and building attenuation. Using these results, the capacity and the transmission ranges available from the potential technologies, such as CT2, DECT, CDMA and DCS1800 have been estimated for the residential and CBD CAN and PCS environments. Current studies are assessing the benefits of potential performance enhancing techniques such as equalisation and macrodiversity, to improve the reliability of the radio link for CAN access and PCS.

The results of these studies will facilitate AOTC's planning and network design for the CAN access and PCS and will ensure that the most appropriate and cost effective radio technology is chosen.

Mobile & Personal Communications Technologies Growth & Capacity Trends



Code Division Multiple Access for Future Mobile Communication Services

Researchers at TRL are studying the potential performance and cost advantages of Code Division Multiple Access Cellular (CDMA Cellular) compared to the TDMA digital mobile telephone systems soon to be introduced in many countries. They also contribute to CCIR working groups which are developing standards for future public mobile telecomm-unications systems.

Digital cellular systems will soon be introduced to meet the rapidly growing demands for mobile phones and data services, and for radio access in the Customer Access Network (CAN) and Personal Communications Services (PCS). Typical systems use low-rate digital voice codecs and Time Division Multiplexing (TDMA) of several traffic channels onto each radio channel. The USA's Digital-AMPS system will fit three channels into each existing analog channel, and the European GSM system will achieve about the same capacity improvement but will use new band allocations.

However, there may be substantial disruption to existing mobile customers. First, in the USA because Digital-AMPS requires 33% of the analogue spectrum to be converted if it is to meet just one year's traffic growth without new base stations; second, in Europe if the existing analogue cellular spectrum is re-allocated as GSM spectrum is taken up.

By contrast, CDMA Cellular has up to 20 times the capacity of AMPS and several times higher capacity than any other forthcoming cellular system. This capacity advantage means an easier transition to digital cellular, with less disruption to existing customers, and less requirement for new base station equipment. Additionally, CDMA cell site positioning is less critical than for other systems, and it is exceptionally resistant to transmission distortion in shadowed areas.

CDMA is also well suited to future PCS and business portable communication systems. The same terminals could be used with public cellular systems, private business systems, domestic cordless, and possibly even with remote area satellite systems. And most importantly, the high spectral efficiency provides the traffic capacity for a consumer market.

Inter-exchange Optical Network Developments

Telecom Australia is currently installing an extensive single-mode optical fibre transmission network linking Australia's major cities and provincial centres. Researchers at TRL are exploring the potential scope for significantly enhancing this evolving network to provide the higher transmission capacity needed to serve Telecom's customers far into the 1990s and beyond.

At present, transmission over the long-distance optical network is provided using 140 and 565 Mbit/s transmission equipment with typical repeater spacings around 50 to 60 km. In the future, as the demand for transmission capacity grows, 2.5 Gbit/s transmission equipment will be required.

Recent advances in transmission system technology at 2.5 Gbit/s have made it possible to control the effects of laser diode chirp (change in output optical wavelength as a function of the data pattern). Therefore, it is possible to maintain present repeater spacings on installed fibres at 1550 nm where the fibre loss is low but fibre dispersion is high. These higher capacity systems can now be installed into the long-distance inter-exchange network with confidence.

In the longer term, the transmission capacity of the long distance network could be increased in many ways. Optical amplifiers are recognised as a key technology required to achieve this aim. They allow an array of optical signals, each at a different optical frequency, to be amplified in a single device. They can also be used as power amplifiers to boost the transmit signal level, and as pre-amplifiers to improve the sensitivity of optical receivers.

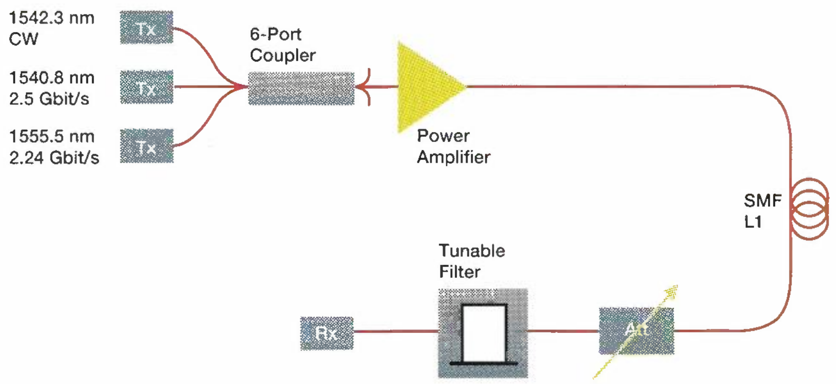
For long distance point-to-point applications a power amplifier could be used at the transmit end, and a pre-amplifier at the receive end to maximise the total transmission distance. To add flexibility to the network, intermediate regenerators would be replaced with in-line optical amplifiers. Then, any future upgrade in the transmission capacity could be achieved by simply upgrading the line transmission equipment at either end of the link or adding additional transmission equipment using wavelength division multiplexing (WDM).

The two main types of optical amplifiers – semiconductor and doped fibre – are being investigated at TRL. This involves both analytical modelling work and the development of prototype amplifiers to demonstrate the capabilities of these devices in both intensity-modulated direct-detection, and future coherent optical systems.

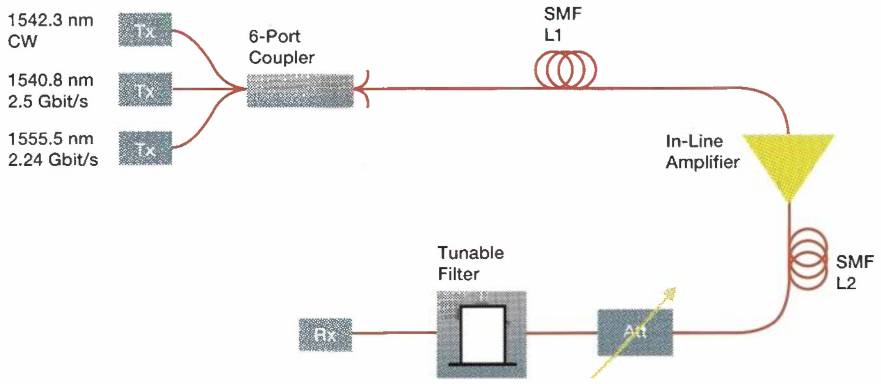
Summary of the demonstration system performance

	Configuration	System	L1 (km)	L2 (km)	Total Length (km)	Power Penalty at BER=10^{-9} (dB)
A	Power Amplifier	WDM	141	-	141	0.8
B	In-Line Amplifier	WDM	60	106	166	1.8
	In-Line Amplifier	Single Channel	106	95	201	3.5

A. Transmission system incorporating an optical power amplifier

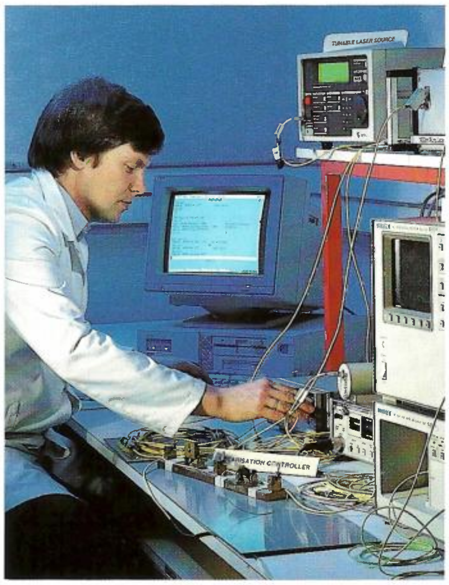


B. Transmission system incorporating an in-line optical amplifier



TRL recently demonstrated several future network applications using in-house developed doped fibre optical amplifiers. In the demonstration, the optical amplifier was used as either a power amplifier or an in-line amplifier and the distances achieved at 2.5 Gbit/s were tabulated. Results confirm the potential impact that optical amplifiers will have on future network design.

Developments in the long-distance network will be significant in the years to come. As new technologies become available to customers, TRL will continue to exploit the enormous transmission capacity of Telecom's installed optical fibre network.



Researcher Dr Frank Rühl characterises Erbium doped optical fibre amplifiers for use in high speed trunk transmission networks.

Digital Network Synchronisation

TRL provides Telecom Australia with time and frequency standards to provide synchronisation information to its own national and international telecommunications networks and to many customer private networks.

An essential part of a digital switch or transmission system is a "clock" which ensures timing information for the control and sequencing of information processing and flow. Timing information must be transmitted throughout the network in a planned and controlled way for the error-free operation of a digital telecommunications network. Controlled timing, by means of a Synchronisation Network makes sure that data transfer through the multitude of switches, crossconnects, multiplexes and transmission systems is performed without "slips" which would result in loss of information.

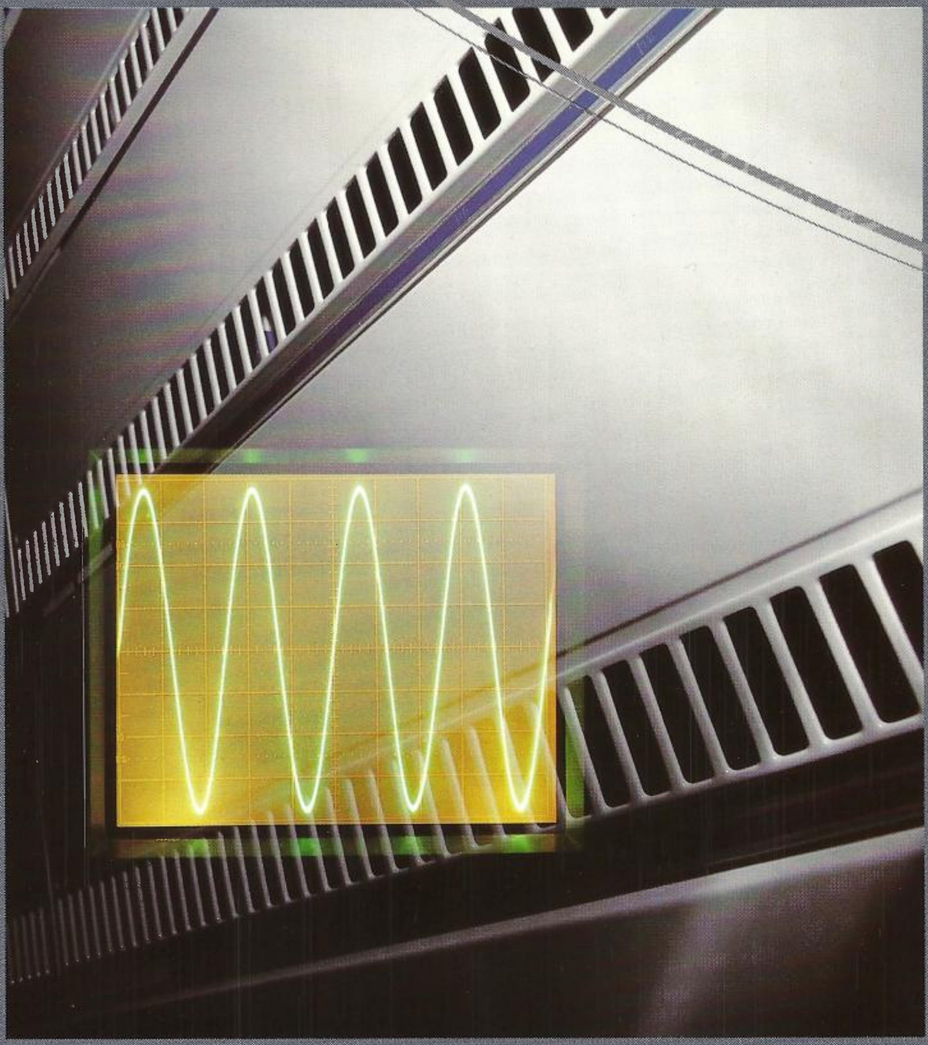
New services and network technology place increasing demands on the performance, operation, and verification of Telecom's network. So, Telecom is implementing an upgrade to the performance of its synchronisation network to meet those new demands.

In a large exchange, the clock system of a switch may control the timing of thousands of circuits which terminate on that switch and pass synchronisation on down the clock hierarchy. Thus, all services are dependent on the performance of the clock at that switch. As a consequence, network synchronisation must be designed to support the most demanding services, such as secure voice and data, video, and facsimile, and must have high redundancy and back-up for high reliability.

In 1985, TRL designed the National Reference Clock incorporating the existing frequency standards. The National Reference Clock supplies the frequency reference and verification to the UTC time scale required by CCITT Rec. G.811 for the synchronisation hierarchy of all clocks in the digital networks.

In addition, TRL plays a leading role in the planning, assessment and implementation process which network synchronisation is currently undergoing within Telecom. As part of this role, TRL has commenced a monitoring programme to gather synchronisation performance data from clocks around the network. Researchers at TRL have also studied overseas initiatives in the synchronisation field and incorporated these findings into its recommendations on the future direction of Telecom's synchronisation network development. Furthermore, researchers have commenced some discretionary research into the synchronisation problems associated with inter-connection of networks as they affect the operation of both Telecom and customer private networks.

TRL's synchronisation studies and developments are of paramount importance as customer demands for new and more complex network services place increasing pressures on the network.



TRL plays a leading role in the planning, assessment, and implementation process which network synchronisation is currently undergoing within Telecom.

Developments in electronics and photonics, expected to come to fruition later this decade, will allow optical fibre to become ubiquitous and an array of video and other broadband services to become affordable to the majority of the community.

DEVICES AND TECHNIQUES

Judging which new technology will make an impact on telecommunications networks and services, and in what timeframe, has always been something of a guessing game. Technology shifts only proceed if and when performance, cost, reliability and market factors are favourable.

Electronics and photonics are the two major enabling technologies for telecommunications, and many revolutionary developments, particularly in photonics, are expected to come to fruition later in this decade allowing optical fibre to become ubiquitous and an array of video and other broadband services to become affordable to the majority of the community.

A transition from electrical to photonic predominance in the network will most likely occur, but, with what technology and when? Will organic materials come to dominate photonic technology just as they have come to dominate many other materials areas? What part will superconductors play? How should you power a photonic network? Will fuel cell technology find application in the network? What about the new breed of ceramics? When will molecular electronics become a practical reality? How much will the photonic "box on the wall" cost? What technology will be in it? Questions are easy to ask. TRL's job is to provide answers (and to ask some questions as well!). The diversity of new technological possibilities in this area of TRL's activity is always intensely interesting to the research staff. However, because TRL's resources are limited, and business pressures tend to emphasise the more immediate term, it is only possible for TRL to work in selected key areas of forward looking materials technology.

The items reported here are drawn from both newly emerging materials, devices,etc., and work on new techniques of experimentation and analysis relevant to materials.

Researcher Barry Hawkins examines new gel filled batteries which are undergoing tests at Telecom's Brunswick Telephone Exchange.

New Power Technologies and Systems

The telecommunications network is only as reliable as the energy source that powers it. To maintain reliability for Telecom Australia customers, TRL independently laboratory tests power conversion equipment and battery technologies that have undergone major changes in recent years.

Mains electricity powers most of the network and the incoming energy is converted to 48 volts DC which supplies the equipment and keeps batteries fully charged. The batteries allow services to be maintained in the event of a loss in mains power.

In remote areas where mains power is not accessible Telecom Australia often uses solar power, but again batteries play a vital role in providing energy at night and on days with low solar input.

Traditionally power conversion from mains to 48 volts DC was performed at the 50 Hz mains frequency. Such equipment was physically large and heavy, and because it was inefficient, electrical energy was wasted and heat generated. A new class of power conversion equipment based on high-frequency switching techniques offers advantages in space, weight, efficiency, performance and features but there is some concern over its reliability and compatibility with other electronic equipment.

The lead-acid battery is still the dominant technology but in recent years the traditional flooded cell has been displaced by the newer valve-regulated type. However, there is still no way to accurately measure the amount of energy stored in a battery other than discharging it. Such testing is too costly and time consuming to be considered to be part of routine maintenance, particularly at remote and unmanned sites.

By monitoring the performance of a power system it is possible to detect faults and deterioration of components and predict the level of energy reserve stored in the batteries. Power system monitoring is gaining momentum worldwide and there has been rapid growth in the range and variety of equipment to perform this function.

However, it is not clear whether the introduction of presently available monitoring equipment into the network would be cost effective. Not enough is known about the best methods or the appropriate parameters to monitor. Expert interpretation of the collected data is still required. TRL has therefore undertaken a number of investigations aimed at providing a better understanding of the requirements and usefulness of power system monitoring.

A project which was established to evaluate the performance of different battery types used in Digital Radio Concentrator Systems (DRCS) has enabled research into monitoring techniques. Data logging of all relevant power system parameters at remote solar-powered DRCS sites has allowed the identification of critical parameters. On-line manipulation of the data acquisition processes provides valuable information about optimum sampling rates and data resolution which can then be used in the specification of monitoring equipment for the network.

Recently, TRL conducted comprehensive tests on the first installation of new power conversion and battery technologies in the power system at Brunswick Telephone Exchange and is continuing to monitor their performance during the first year of operation.

The new batteries at Brunswick Exchange are the valve-regulated type and have a gel electrolyte. The batteries are mounted on their side with the terminals at one end which allows them to be stacked six high, thus saving much floor space. However, there are fewer indicators of the battery condition. The internal plates are not visible because these batteries have opaque cases, and the specific gravity of the acid gel cannot be measured.

Monitoring equipment that TRL has installed at Brunswick measures almost 150 parameters in this new power system including the voltage of each of the 96 batteries, the currents into each of the four battery strings, the current from each of the ten power converters, and temperatures of selected items of equipment. These parameters are measured every 10 seconds and processed before storage. Data is downloaded daily through a telephone line and modem to TRL for analysis and evaluation.

In the laboratory a relatively new and advanced technique is being developed in which a battery's impedance characteristics can be correlated to its discharge performance. Presently, a prototype instrument is being developed based on this technique that might be used in the field to quickly and reliably assess a battery's condition.

Work carried out by TRL ensures that alternative power sources for the sometimes harsh and inaccessible Australian telecommunications network are the most up to date, reliable , and cost effective available.

Power Transmission using Optical Fibre

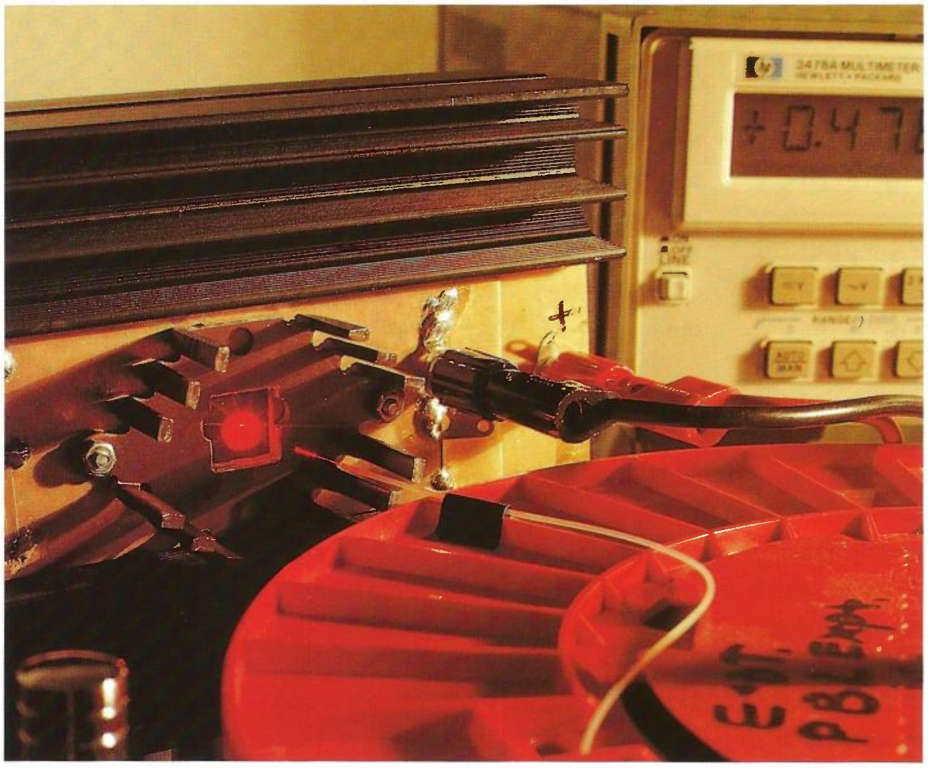
The introduction of optical fibre to customers' homes will provide several enhanced and new services to Telecom customers. However, because of the lack of metallic conductors in optical fibre cable, TRL is developing new methods of powering the telephone.

Presently, the telecommunications network is powered by mains electricity with batteries to cover periods of power outages. Capital and maintenance costs favour having a large, centralised battery installation, so the battery-backed power is usually transmitted over the same pair of wires used to carry the voice signals. Most of the optical fibre cable installed by Telecom, however, contains no metallic conductors for power transmission. Thus, alternative techniques must be found if power is needed at the end of an optical fibre link.

One possible solution is to convert electricity to light, transmit this light along an optical fibre and re-convert it back to electricity at the remote end. This can be done with reasonable efficiency by using a solid-state laser diode as the light source, a multi-mode optical fibre and a silicon solar cell detector. The laser provides a monochromatic light and the wavelength is selected to minimise losses in the fibre. Because the light source is monochromatic, the detector can be designed to have a much higher efficiency than a conventional solar cell that is designed to detect a wide spectrum of radiation. It must also be designed for higher levels of light than sunlight.

An experimental system using a YAG laser has been developed to demonstrate this power transmission technique. At the receive end more than 1 Watt of electrical power has been achieved after transmission over 200 metres of fibre. The technology for both the solid-state lasers and the detectors is advancing rapidly and so this figure can now easily be exceeded. The next phase of the project is to replace the YAG laser with a solid-state laser diode.

The lasers and detectors necessary for this form of power transmission are still relatively expensive, overall power transmission efficiency is a low 6% at present, and there are some fundamental upper limits. However, as with most optoelectronics, device costs are expected to fall, device efficiency improve and this technique is still a possible option for special applications and when the local source of mains power is lost.



A solar cell is an effective way of converting light transmitted by optical fibre to electricity to power Telecom Australia's remote equipment.

Advances in Optoelectronic Devices

The Lightwave Technology Group at TRL is developing and investigating lightwave communications subsystems. A major focus at present is the development of prototype optoelectronic transceivers suitable for bringing fibre to the subscriber, while meeting stringent technical specifications to carry the anticipated range of voice, data, and video services. They must also be suitable for mass production at low cost.

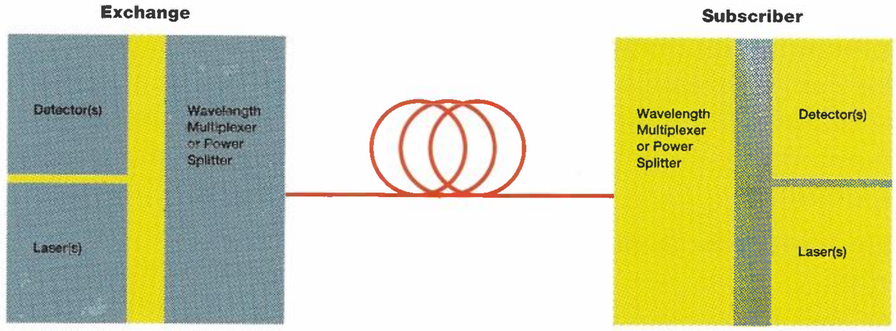
To create a laboratory prototype transceiver, suitable optoelectronic components such as lasers and detectors must first be developed and then integrated both with each other and with planar optical waveguides. In turn, the planar waveguides must be connected to the outside world via optical fibre pigtails. Pig-tailing, waveguide, integration, and semiconductor optoelectronic technologies are being pursued concurrently at TRL.

In the semiconductor optoelectronics area two different detector technologies have been under development. First, heterostructure bipolar phototransistors using Indium Gallium Arsenide Phosphide; and second, Metal Semiconductor Metal (MSM) photo-detectors using Mercury Cadmium Telluride. These devices are considered to be well suited to the application because of their potential for high level integration. Advanced material fabri-cation and photolithographic masks for a new generation of bipolar photo-transistors have now been completed, based on the experience gained with TRL's first generation of these devices.

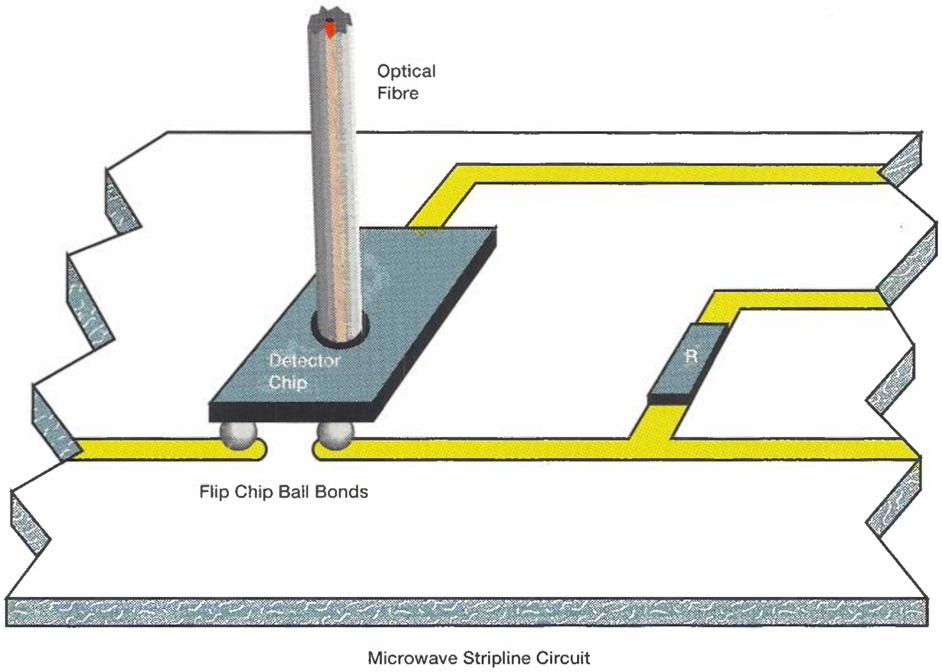
Achieving efficient electrical and optical interconnection of these detectors with the outside world is a significant challenge. Electrical connection between microwave waveguides and the optoelectronic device is made via solder bump bonds, 50 μm balls of solder attached to 20 μm contact pads for low capacitance. The flip-chip technology to form such connections has been developed at TRL. A fibre pigtail is also required on these devices, and a precision aligning and packaging device has been developed at TRL to enable an optical fibre to be positioned accurately over the 20 μm diameter active area of a detector, to apply a bonding adhesive and then to enclose the whole device in a sealed protective package.

A Mercury Cadmium Telluride MSM photodetector has been developed at TRL to cover the 1.3 μm wavelength communications window. The detector has a sensitivity of 0.4 A/W and a 3dB bandwidth of approximately 200 MHz. A feature of this device is the slow decrease in sensitivity with increasing frequency, with useful response extending to several GHz. A model has been developed for this device and the dominant characteristics of the frequency response can be explained in terms of defect states at the metal semiconductor interface.

A CAN test bed has been designed to trial TRL optoelectronic components



Two optical transceivers communicating over a single optical fibre



A fibre pigtailed optical detector "flip-chip" bonded to a microwave circuit.

thereby allowing assessment in a realistic communications environment. Integration of these components will lead to the evolutionary development of optical transceivers for the Customer Access Network.

Fibre Devices for Switches and Filters

They reflect, they resonate, they can be made to amplify and store light pulses, they filter, they block light in one direction but pass it in the other, and they can change the shape of light as it passes through depending on its brightness. What are they? – they are optical fibres and componentry in their growing number of forms. The surge of interest in all-optical photonic communications now means that this fibre componentry is coming together to make complete systems. If the 1980s was the decade when optical fibres took lightwave telecommunications to the darkest corners of the world, the 1990s will be the decade when fibres will help control and process it.

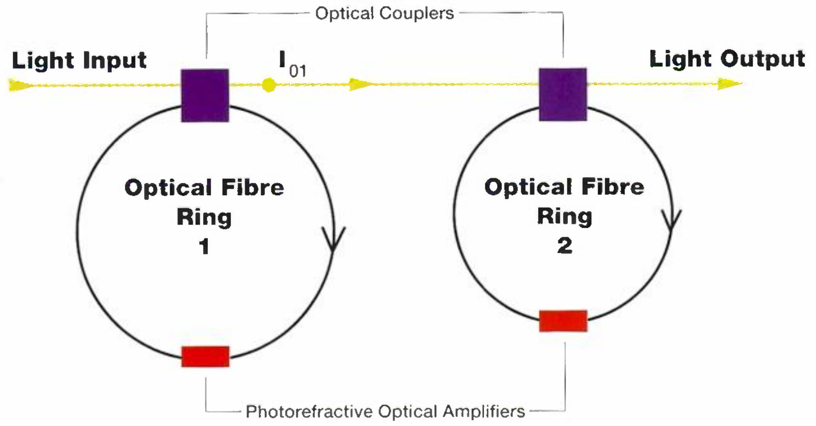
Researchers at TRL are considering ways to expand the capacity of the communication network by more clever use of optical fibres. There are basically two ways to proceed to achieve higher capacity: either allocate signals to different time slots (time division multiplexing), or to different wavelengths (wavelength division multiplexing). Fibre components can contribute to both strategies because the optical fibre medium offers strong confinement in the core, long interaction lengths, and compatibility with the transmission medium.

Fibre loops can act as a fast optical switch. Whilst silica is a particularly linear material, the long interaction lengths experienced in fibres can produce remarkable nonlinear effects including wavelength shifts, such as that observed from Raman scattering. The optical Kerr effect is more subtle, causing an additional phase shift of light passing through fibre which has been appropriately stimulated. A fibre loop spliced to an unequal coupler will switch optical pulses to different coupler ports depending on power level, since pulses travelling clockwise around the loop experience a different phase shift to those travelling anti-clockwise. Such a device could be the basis of combining say 100 individual 1Gbit/s signals into one 100 Gbit/s signal.

Fibre loop resonators can act as a wavelength switch, routing a range of wavelengths to one fibre whilst passing the rest to a second. Many forms of such channel dropping and passing devices are possible and a whole family of them have been studied at the Research Laboratories. Of particular note is a double loop vernier device (as seen in the diagram) which can be designed to pass, or block, one channel while suppressing the next N successive channels, with N typically 1 to 10. The addition of optical gain by coupling photo-refractive crystals to such devices to adjust finesse or bandwidth has been explored theoretically.

The unique properties of fibre componentry that are being analysed at TRL will play a significant role in shaping directions for increasing the capacity of telecommunication networks.

Double Ring Vernier Resonator



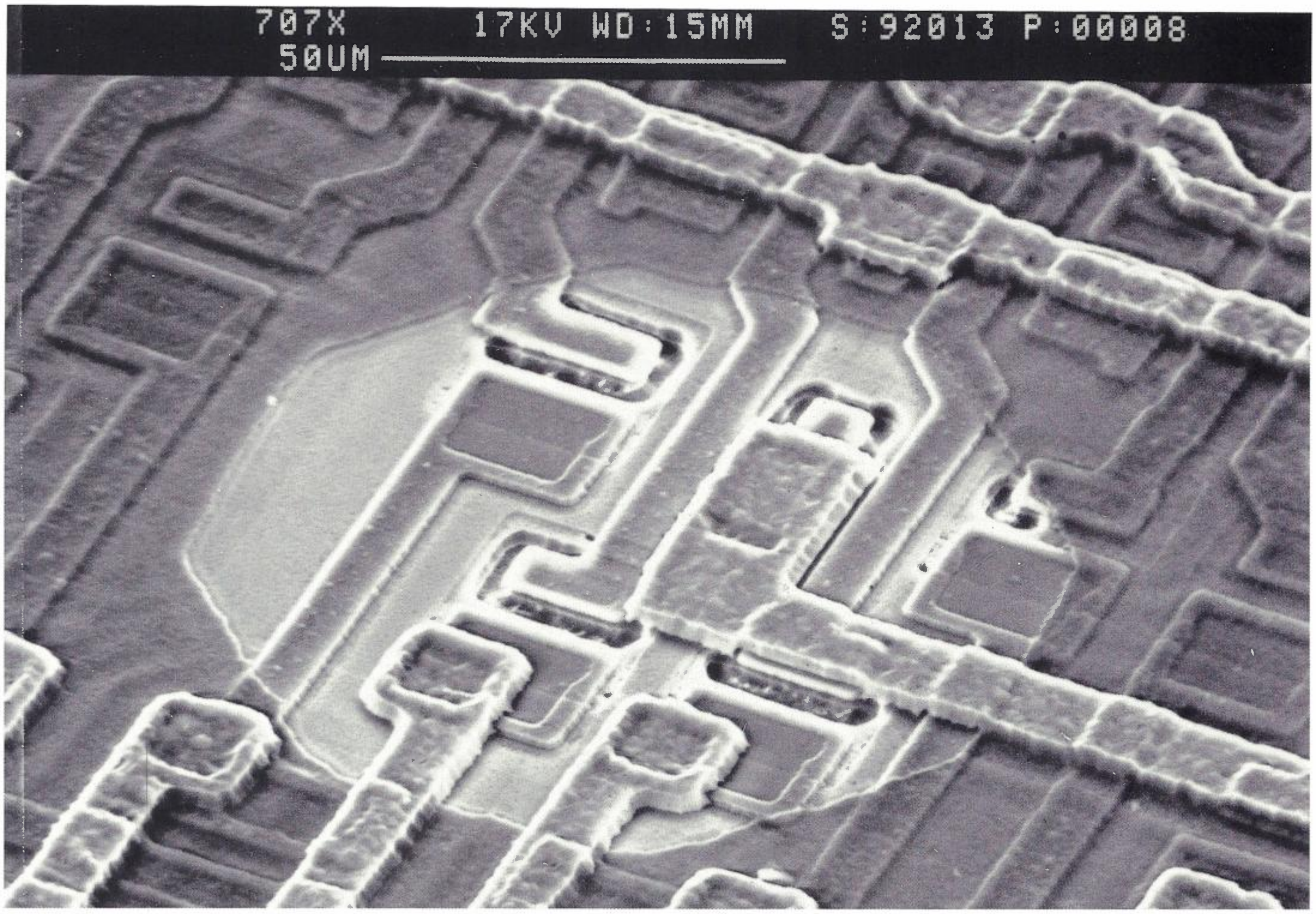
TRL's Double Ring Vernier Resonator has applications in future high capacity Wave Division Multiplexing networks.

Selective Etching of Integrated Circuits

The widespread use of application specific integrated circuits in telecommunications network equipment demands that expert researchers at TRL develop and apply increasingly sophisticated techniques to examine reliability and causes of failure in these components.

A routine requirement during the failure analysis of integrated circuits is the need to take devices apart layer by layer to locate and examine any failure site which may be present. However, this task is becoming more difficult due to the increasing complexity of integrated circuits. Not only have the dimensions of individual transistors been reduced to sub-micron dimensions, but there can now be three or four separate layers of metal used to connect them. This makes access to the lower layers of the circuit difficult, especially where power supply tracks having relatively large dimensions cover those sections of the circuit requiring closer investigation.

Whilst the removal of one or two layers is relatively straightforward, complications arise where several layers are involved. One of the most important considerations is that fault sites are not affected by the process used to remove the overlying material. Gaining access to the circuit, but leaving the fault undisturbed, is even more critical when the circuit is required to continue to



The octagonal area indicates the selectively etched portion of the circuit.

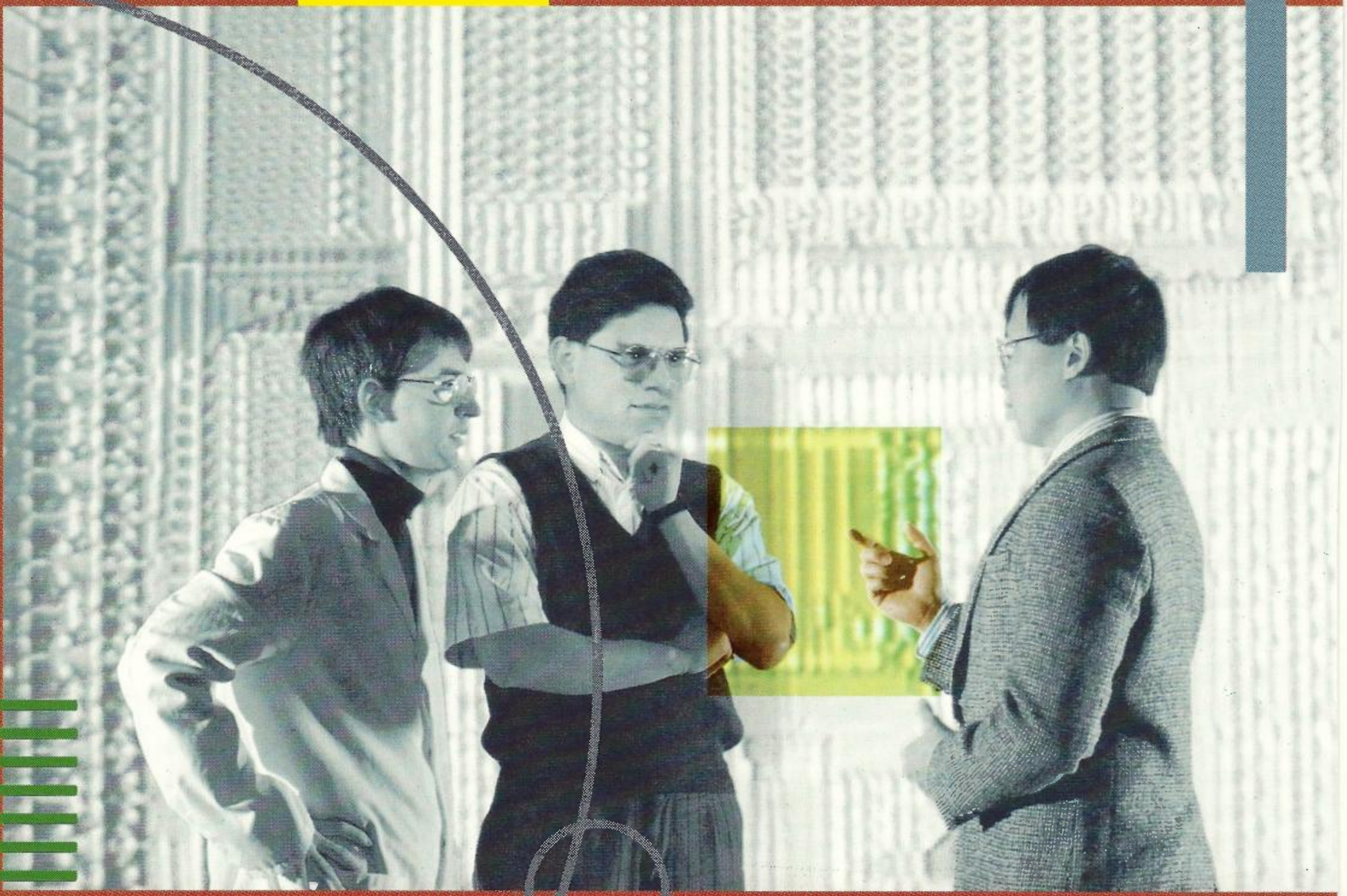
function so that measurements can be taken. In this case, some type of selective etching is needed to access individual transistors while leaving the remainder of the circuit undisturbed. Occasionally, it may even be necessary to partially remove some of the overlying metallisation without open circuiting any of the tracks.

To provide this selective access, plasma etching (which is the preferred means of removing complete layers of material from VLSI circuits) is combined with a mask consisting of a polymer based resist. This enables "pits" to be etched in desired locations, thus providing access to individual points on a circuit while leaving the rest of the circuit intact. Although these processes are essentially the same as those used to fabricate the circuits, additional complications arise when working with packaged devices. For example, it is difficult to achieve a resist layer which is even and of the required thickness over the whole of the circuit, especially near the edges where the bonding wires connect the silicon die to the package lead frame. Other problems can occur during etching because of interference from some of the packaging materials with the plasma etching reactions.

To provide the mask for selective etching an electron beam resist is used. Exposing the resist is accomplished using a scanning electron microscope which enables the high degree of precision needed. A computer is used to control the movement of the electron beam over the resist, and any arbitrary shape can be defined. After the integrated circuit is removed from the electron microscope the resist is developed. Only those areas of resist exposed to beam are removed and the remaining resist acts as a barrier, or mask, which protects the rest of the circuit during the etching process.

Portions of the overlying metallisation can also be removed using a similar process with appropriate changes to the gas mixture used in the plasma reactor.

Customers will be able to use conferencing and multimedia services to access multiple parties and to enhance the exchange of information within a call.

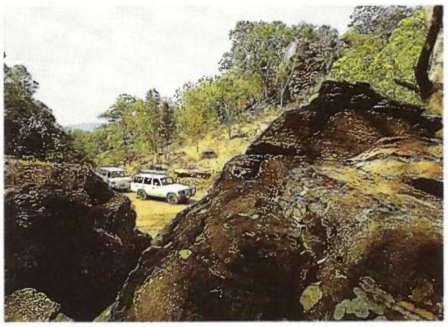


SWITCHED NETWORKS

Developments in network technology taking place at TRL will have profound effects on future possibilities for the construction and delivery of communication services.

Important changes are taking place in fundamental technologies of switching, signalling and in the possibilities of management of the diverse capabilities of modern networks. TRL carries out co-ordinated research programmes in each of these spearheading areas, including broadband services and communication, Intelligent Network control and service development, and in new possibilities for network management.

Service flexibility and the expected inclusion of many different communications media and connection capabilities in one network lie at the heart of current broadband networking concepts. Demand to exploit multiple media connections including many forms of visual data will increase. Customers will be able to use conferencing and multimedia services to access multiple parties and to enhance the exchange of information within a call.



Significant advances are foreseen in the capabilities of new signalling systems which will be needed to support broadband services. The expected flexibility of new broadband switching technologies is mirrored in the more advanced flexibility and capacity to handle diverse connection requirements that are being planned as longer term capabilities of network signalling. TRL is participating in, and leading where necessary, the international developments which are establishing the guidelines and techniques to be adopted to provide these capabilities. The results of such a process are expected to be evolutionary paths as well as easy compatibility with pre-existing networks.

To apply these advances, TRL is exploring possibilities through conceptual studies and through design and prototyping studies in collaboration with industry development groups in Australia. This work will ensure that Telecom is well placed to provide customers with services based on new capabilities as the promise of broadband technology matures.

Developments in techniques and standards for Intelligent Networks will also impact on telecommunications services. In the medium term, Intelligent Networks will be able to deliver results in a more flexible and rapid service design and introduction. They will be helped by standards developments now coming to fruition. The International Telegraph and Telephone Consultative Committee (CCITT) is at the centre of international work to realise these aims, and TRL is a major contributor.

While new services can be introduced with increasing flexibility and a degree of customisation, similar needs also exist for developing the internal operation of networks. TRL is active in internationally-based developments bringing together communications and computing techniques to support operations systems. Other studies are being carried out on aspects of network operation, such as the optimised management of bandwidth in the network. This work will allow cost savings and improvements in network connection quality and robustness of operation.

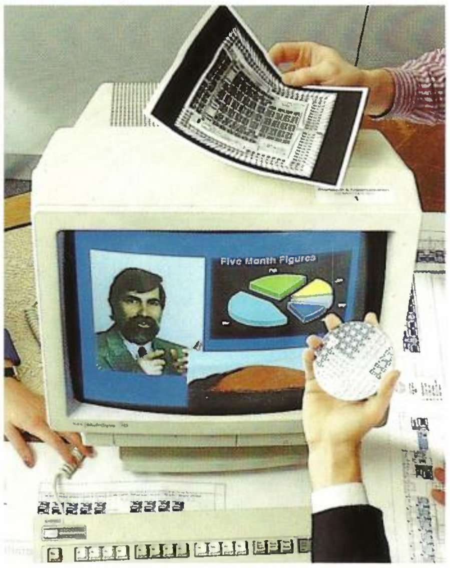
These technology advances are also challenging teletraffic engineers to find new approaches to analysing network structures and operation. Teletraffic engineers at TRL are extending the methods of teletraffic engineering to solve the new problems in network dimensioning and performance thrown up by service advances.

The pages of this chapter describe in further detail some aspects of the work TRL is doing to make possible advances in new network services, and to move these closer to reality.

Multipoint Multimedia Networking

Imagine engineers, product designers, and developers in different parts of the country, perhaps different parts of the world, being able to design together and interact as though they were sharing the same office or laboratory facilities, browsing through the same report, and sketching their ideas on the same whiteboard.

TRL is working on initiatives to include such flexible multipoint and multimedia (voice, text, video, and graphics) capabilities in future networks that brings the above scenario much closer to reality. Already an increasing number of businesses, industries and individuals rely on the electronic exchange and manipulation of visually based information, often in combination with other information types.



Researchers at TRL are working on initiatives to include flexible multipoint and multimedia capabilities in future customer networks.

TRL's work centres on the desire for new and enhanced means of managing the production, processing and transportation of information to satisfy customers' instantaneous communication requirements.

Two major problems pose an impediment to the widespread development of multimedia communications over existing public networks.

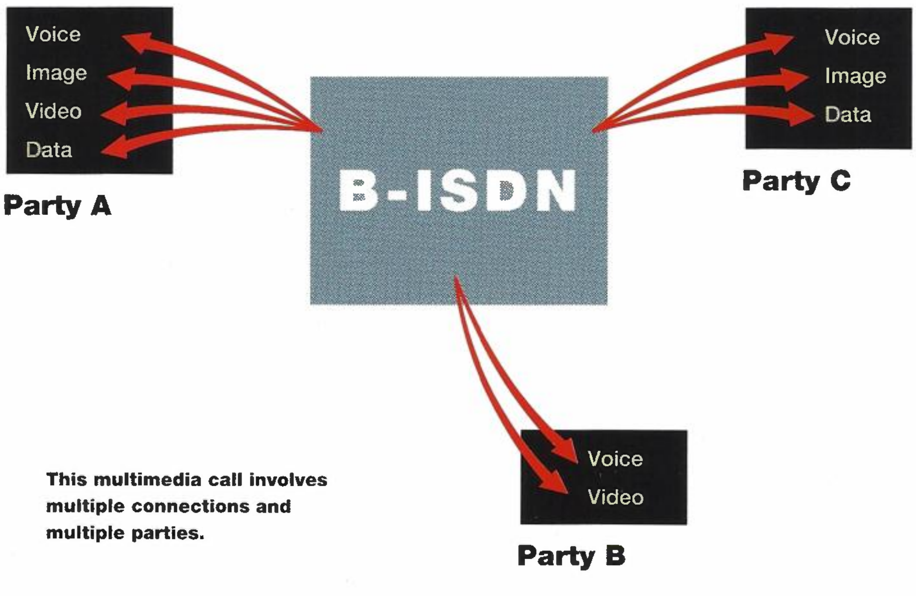
First, the difficulty of transporting information in a timely manner when relatively enormous amounts of visual data are involved. Second, the difficulty establishing and managing a responsive collaborative/interactive communications environment. Current telephony networks offer services based on point-to-point, single channel connections between customers.

Existing solutions for providing multipoint and multimedia services overcome the limitations of existing networks by placing the necessary functionality in customer terminals or dedicated hardware. Solutions of this kind necessarily constrain multimedia service access, range and type.

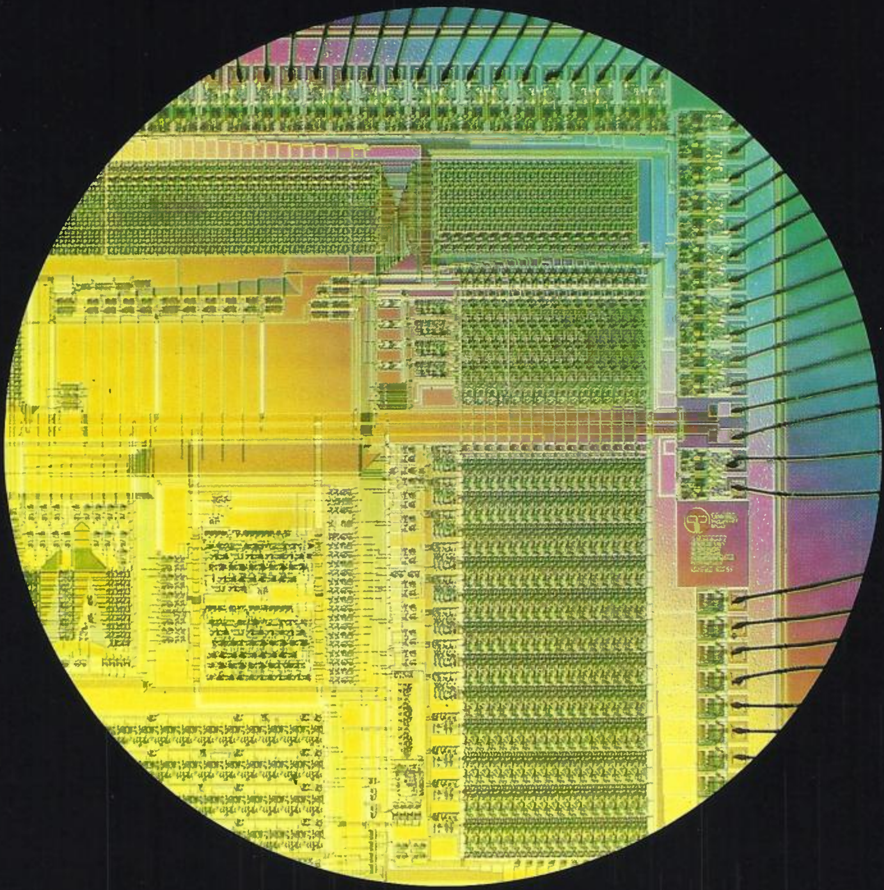
In contrast, service integration lies at the heart of the B-ISDN concept. The rapid transportation of multimedia information streams will be supported by high performance transmission and transfer modes such as optical fibre and digital cell based systems, with inherent multipoint capabilities.

Satisfying future customer demands for direct control and highly personalised, multimedia services will require complex connections in which multiple channels are co-ordinated serving multiple destination parties.

Future multimedia communications will be flexible and dynamic, changing not only between calls but also within calls through the flexible addition and deletion of media and parties.



This multimedia call involves multiple connections and multiple parties.



Separation Signalling for Broadband Networks

TRL is currently playing a significant role in the CCITT to develop powerful and sophisticated signalling methods for broadband networks. This will give customers a much greater variety of services and higher levels of control over the services they wish to use. For example, participants of video conferencing services will be able to enter and leave as required, send faxes and other documents to individual participants, and make side calls to parties not in the conference.

The CCITT has recently agreed that to support advanced broadband services, in particular, services with multiple connections, it will be necessary to introduce separation of call control from the individual control of bearer connections. In broadband networks, 'bearers' refer to the individual service-related bit streams that go together to make up the total service package required between users for a call. The call control will perform functions relating to the entire call, such as checking compatibility of the destination terminal, and will co-ordinate the individual bearer connections. Each bearer control will be responsible for the complete control of a single bearer connection.

This separation will allow a modular approach to be taken to supporting advanced services and thus reduce their complexity. For a call with multiple connections, the corresponding number of bearer control functions will be required. This will minimise the interaction between separate bearers and allow an arbitrary number of bearers to be used in a single call.

Another feature of the design of broadband signalling is the possibility to maintain commonality between the access and the network signalling protocols. This should avoid the need to maintain two separate sets of signalling protocols – a considerable advantage on present methods. Furthermore, care is being taken to ensure that the signalling can evolve cleanly from present day signalling for the 64 kbit/s ISDN and between various releases of signalling for B-ISDN. This requirement is being attained by the introduction of powerful compatibility mechanisms into B-ISDN signalling. Finally, the design will incorporate appropriate facilities to link in network management protocols.

As well as calls with multiple connections, signalling in the B-ISDN will support the delayed establishment of bearer connections, and negotiation of bandwidth and other traffic parameters during call establishment and midway through the call. Additionally, it will support independent routing of bearer connections, the provision of point-to-multipoint connections, the ability to add parties to multipoint connections, and a wide range of supplementary services. These new service requirements will require much greater signalling versatility and will mean that many new signalling procedures need to be developed.

To satisfy increasing demand for broadband services and to match the rapid development of the switching technology, this signalling should be developed within a short time frame. The adoption of separation of Call and Bearer Control as a basis for signalling has provided a sound basis on which this development can proceed.

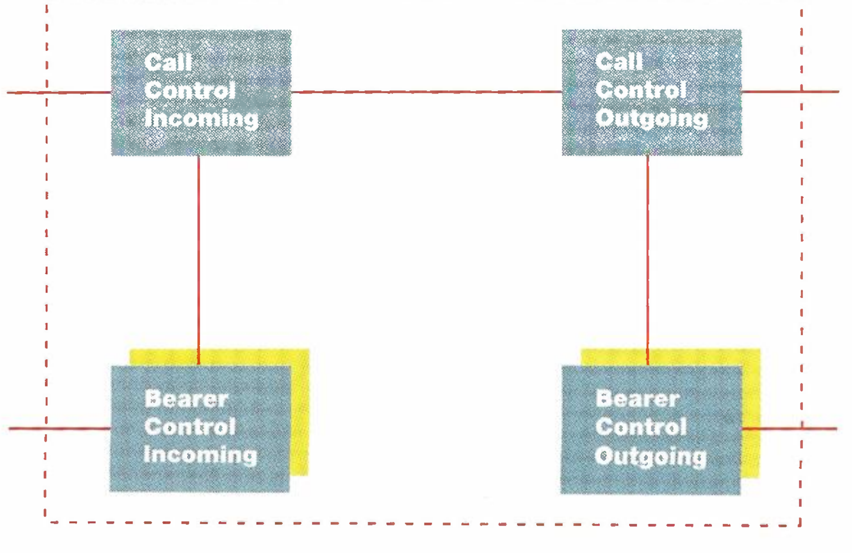
Experimental ATM Network

The Broadband Integrated Services Digital Network (B-ISDN) will allow for powerful and flexible customer integrated services including multimedia, video, high speed data, image and voice transmissions. However, the technology of B-ISDN represents a radical departure from that employed in existing Telecom networks. Researchers at TRL are continuing to develop new skills and knowledge to ensure successful operation of such future networks, and have put in place an experimental network to act as a testing platform for B-ISDN services. Furthermore, TRL has made significant contributions to B-ISDN international standards.

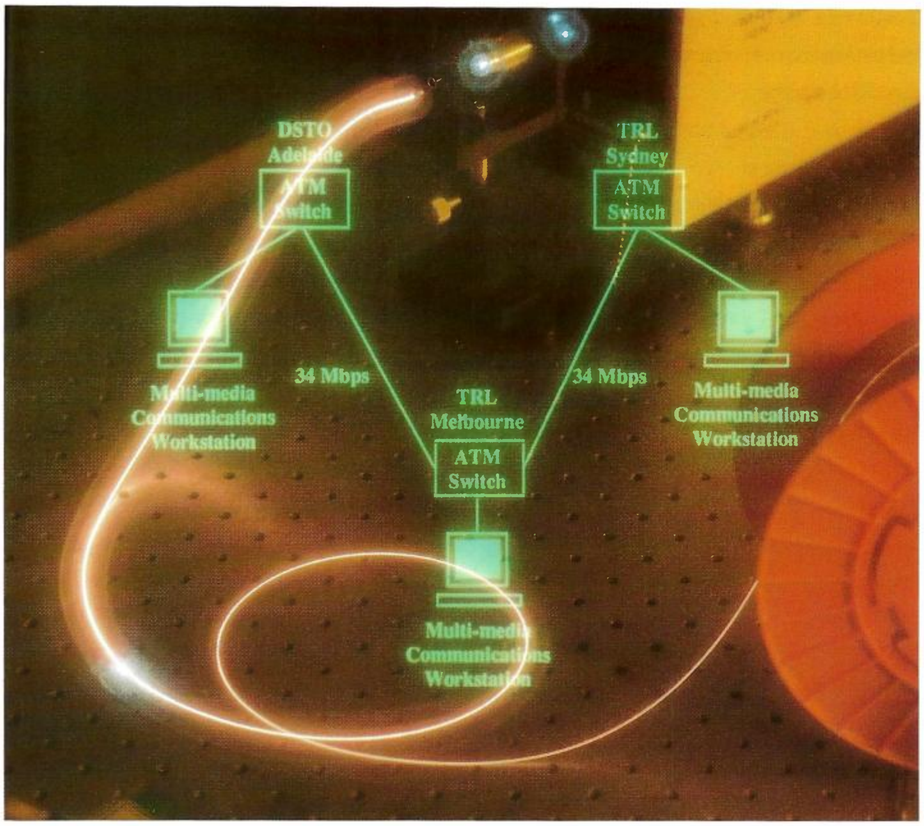
The B-ISDN will be based on the widespread use of optical fibre transmission and new switching technology known as Asynchronous Transfer Mode (ATM). As part of the research work into B-ISDN, TRL is implementing an experimental ATM network in conjunction with the Defence Science and Technology Organisation (DSTO). The network is based on jointly developed experimental ATM switches. Each of these experimental switches may have up to 32 ports – each port operating at a rate of 50 Mbps. Therefore, the switch can have a total throughput of 1.6 Gbps. The experi-mental switches will be located at TRL in Melbourne and at the DSTO site in Salisbury, South Australia.

This experimental network is being used to allow testing of the theoretical principles being developed for B-ISDN. The technical issues of interest include inter-working with other networks (eg. ISDN, Fastpac, radio access), resource management (eg. congestion control), signalling, and the application of Intelligent Network concepts to B-ISDN.

Standards recommendations for the B-ISDN are progressing rapidly within the International Telegraph and Telephone Consultative Committee. TRL's contributions help to ensure that



The functions required at an exchange in order to support broadband services.



Researchers at TRL are using an experimental Asynchronous Transfer Mode (ATM) network between Adelaide, Melbourne, and Sydney to test theoretical principles being developed for B-ISDN.

the standards provided match Australian needs and conditions, and that Telecom is well placed to deploy this technology for the customers' benefit. Consequently, ATM technology for network application can be expected to be available from about 1993 and commercial B-ISDN equipment will be available from about 1995 or 1996.

TRL's versatile and flexible staff have considerable international input to the development of new telecommunications technologies so that Telecom's customers can rest assured that the services they can expect for the future are world class.

New Standards for Intelligent Networks

TRL has been active in supporting International Telegraph and Telephone Consultative Committee (CCITT) work on Intelligent Networks. All developments to Intelligent Networks are monitored and analysed so that TRL can provide expert advice to Telecom to facilitate the introduction of new and improved network services.

The concept of the Intelligent Networks is well established and Telecom already offers Intelligent Network-based services, with its CustomNet product. The CCITT has described the objective of the Intelligent Networks as being "to facilitate service/network implementation.independent provisioning of services in a multi-vendor environment".

The Intelligent Network makes extensive use of information processing techniques and re-usability of modular network functions. Most countries and telecommunications service providers are actively interested in such developments, but until now all products have been vendor-specific, with little or no possibility of direct inter-working between products of different vendors.

The first specifications for Intelligent Networks were issued by Bellcore in the United States in the mid 1980s. These specifications did not meet the ideal of service and vendor independence. After much further work the Multi-Vendor Interaction Forum produced AIN/1 (Advanced Intelligent Network Release 1) which in theory meets all the aims of service and vendor independence. The first phase of implementation of AIN/1 started during 1992.

Since 1989, CCITT has been working towards the development of its own standards for Intelligent Networks. Although American research has made substantial input to AIN, the CCITT work has developed its own direction, while retaining strong similarities to AIN. CCITT has specified phased implementation of Capability Sets, with the initial Capability Set 1 (CS-1) being realisable in current networks.

TRL monitors and analyses all developments in Intelligent Networks to provide Telecom with expert advice for the introduction of improved network services.

CCITT has concentrated its efforts on defining a standardised method of designing new services which could be supported by an Intelligent Network. The AIN description concentrates on the physical architecture, with a generic model of functions which are realised in a physical implementation. CCITT has developed a top-down approach involving re-useable modules which are described in increasing detail until a physical implementation is achieved. The significant advantage of this approach is that the service designer needs to consider only the re-useable modules. All the detailed translation to the physical implementation is precisely defined by the Recommendations and can be easily automated. The Intelligent Network Application Protocol, which is service-independent, is also being specified for transferring information between the various physical nodes in the Intelligent Network. It is expected that this approach will considerably reduce the time taken to implement services in the network.

CCITT realise that the work in defining the CS-1 Intelligent Network is incomplete, but now the best way to advance in Intelligent Networks is to implement CS-1 systems and use the experience gained to improve the specification of later Capability Sets.

The CS-1 Recommendations were effectively frozen after March 1992 and are expected to be approved in March 1993. Work will continue on development of the general Recommendations, CS-2, and long-term architecture.

TRL will continue to participate in leading-edge research on Intelligent Networks so that Telecom Australia can more easily and rapidly introduce network applications that will improve services to the customer.

Towards a Telecommunications Information Networking Architecture

TRL contributes to an international research effort known as the Telecommunications Information Networking Architecture (TINA). The TINA forum is aimed at initiating and consolidating a sound worldwide base for the technological advances needed to bring telecommunications and computing together into an overall information networking architecture, which would be applicable in the mid 1990s and beyond.

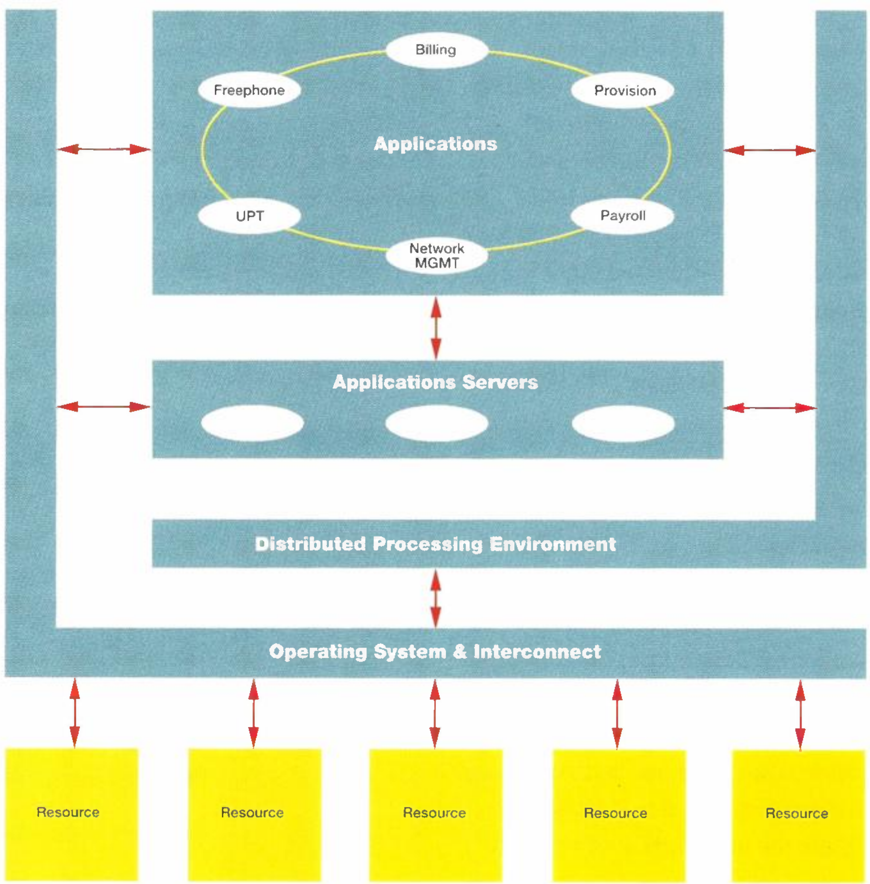
The Intelligent Network concept has been successful in enabling the rapid creation and customisation of new service functionality into the core network, by placing network intelligence in a small number of database nodes in the network. New services are controlled by high level service scripts installed in these database nodes.

As network services increase in complexity and tailoring of services for individual customers becomes common place, Telecom will need an overall architecture which permits rapid customisation of the behaviour of a service, as well as the associated operations systems. This is because operations systems have become an integral part of the overall service package provided to customers. A common framework for network and operations will provide the solution.

This integration of operations support with the core network is a key driver behind long term Intelligent Network research. It will necessitate the development of advanced software and distributed processing techniques to analyse the structure and interrelationships within the telecommunications network and associated operations systems.

The solution proposed by TINA is to enable the integration of network and operations functionality via their execution as applications within a common Distributed Processing Environment (DPE). The DPE shields

TINA Baseline Architecture



applications from the complexities associated with distribution, and permits application portability and seamless interworking. The baseline architecture for achieving this is shown in the diagram. A selection of typical applications are shown to give an indication of the rich mix of functions able to co-exist in an integrated fashion.

A key architectural goal for TINA is to provide appropriate structuring for these distributed applications. Towards this end, TRL is drawing on its software engineering experience by developing object oriented modelling and analysis techniques that can be used to model both network and operations applications in a uniform manner. These models will be the first step towards building a flexible and extensible set of applications and application-servers to be executed within the DPE.

TRL is also building prototypes of various network applications and a simple underlying DPE, to validate the feasibility of the TINA concept. The approach will take a particular service (such as Universal Personal Telecommunications) and implement it as a set of co-operating applications. These applications will support and integrate the provisioning, execution, management and maintenance of the service, within a distributed TINA framework.

The promise of TINA is greater flexibility and new business opportunities, and TRL is developing technologies which will help bring these promises to reality.

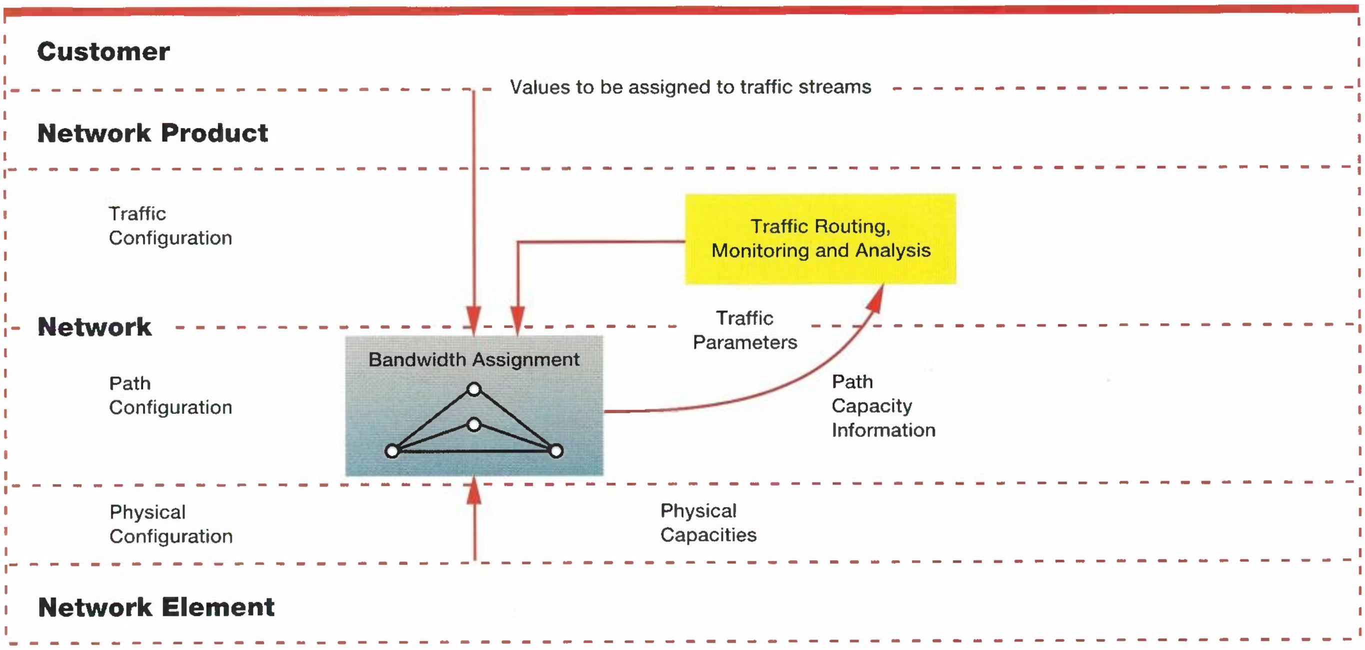
Managing Bandwidth in Switched Networks

The introduction of the Synchronous Digital Hierarchy (SDH) standards for digital transmission has opened up new possibilities for TRL network designers to introduce switched networks that are reliable, efficient, cost effective, and essentially self-healing.

The SDH standards enable two functions to be carried out rapidly and cost effectively. First, they enable network bandwidth to be rearranged rapidly between digital cross-connect devices (DXCs). Second, they permit digital streams down to 64 Kb/s to be added to, or dropped from, the total network payload. These features give network providers much greater flexibility in building and managing highly reliable networks.

There are two circumstances in which network bandwidth may be rearranged. The first case is when the transmission quality of a particular path falls below an acceptable level and a backup path must be activated. This has traditionally been done through protection switching on main routes. The SDH standards make it cost effective for protection switching to be provided throughout the network. Networks then become essentially self-healing, providing extremely high reliability without service interruptions. The key issue here is the placement of DXCs in the network. TRL's network design studies are leading to the design of cost-effective self-healing networks.

Network Traffic Management Optimisation



Bandwidth management fits in a layer of control called "Path Configuration". This set of functions is invoked when transmission quality degrades and when traffic patterns change.

The other circumstance in which bandwidth rearrangement is worthwhile is when the amount of traffic carried by a part of the network is increased. As calling patterns change during the day, it may be beneficial to have more transmission capacity between two points at the expense of capacity on other routes. Transmission capacity between DXCs can be rearranged for this purpose.

The management of bandwidth under traffic load is an area of active research worldwide. Studies overseas show that bandwidth rearrangement combined with an appropriate scheme for call-by-call traffic routing, can lead to significant efficiencies in traffic-carrying capacity. At TRL, our studies show how to arrange bandwidth to maximise the carried traffic; that is, to achieve the greatest possible efficiencies. With these methods, it should be possible to rearrange bandwidth hour-by-hour as calling patterns change throughout the day. Studies are continuing on appropriate call-by-call methods to be allied with bandwidth management for the existing telecommunications networks in Australia.

It is important that these new methods are integrated with existing network management functions. TRL's system studies show how to place bandwidth management within the context of overall network management.

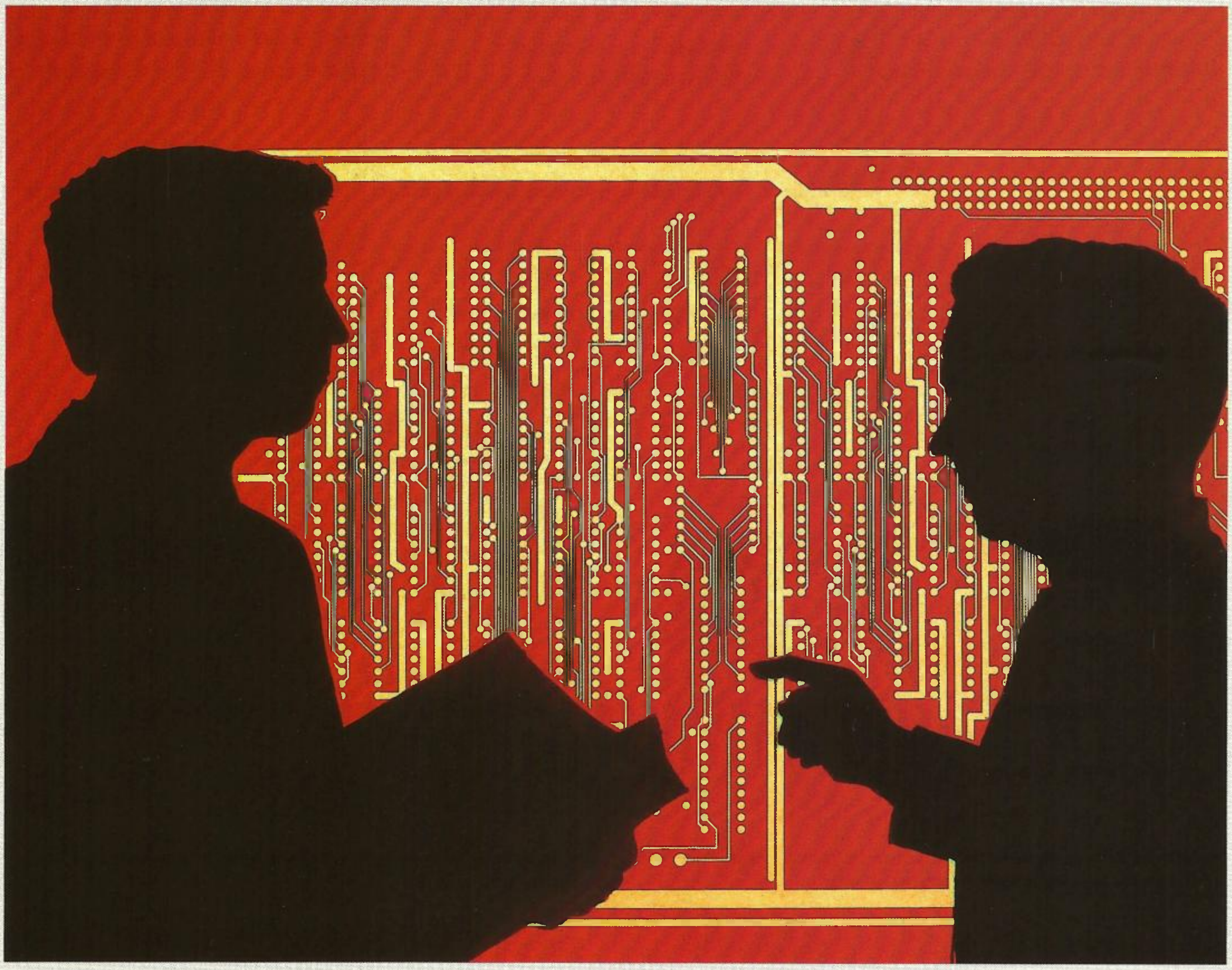
TRL's system studies clearly demonstrate how network management systems and operations may be designed in a way that accounts for bandwidth management functions while reusing existing functions for protection switching and traffic control. Therefore, the new SDH functions should enable a smooth transition from existing technology to the new ones.

Teletraffic Engineering

Teletraffic engineering experts at TRL play a major role in meeting the challenge for designers of future Telecom Australia networks to provide new services with reliability, throughput, and delay performance, at a competitive price for customers.

Teletraffic engineering applies mathematical sciences, including operations research, queuing theory and statistics, and computer simulation. The result is planning, designing, dimensioning, and managing and operating

Teletraffic engineering studies carried out at TRL result in planning, designing, dimensioning, managing, and operating telecommunications networks to economically achieve service objectives.



telecommunications networks, to economically achieve service objectives. Teletraffic researchers at TRL are involved in all phases of a product cycle as it is developed, introduced, incorporated and managed within the network.

Significant contributions related to analysis and synthesis of the Distributed Queue Dual Bus (DQDB) protocol led to its acceptance as the IEEE 802.6 world standard for Metropolitan Area Networks (MAN). The DQDB protocol, which is an Australian invention, is currently implemented in MAN field trials in the US, Germany, France, Italy, and Australia. In Australia, DQDB is the basis for the Fastpac network which will provide high speed services at up to 10 Mb/s interfaces to Telecom's business and corporate customers. TRL researchers provide advice to assist the design and development of Fastpac to achieve a reliable, efficient and cost effective high speed network.

Contributions are also being made to the design of future high speed networks. Teletraffic researchers at TRL are developing a novel protocol for accessing a shared medium in the Broadband Customer Premises Network (B-CPN) which will be connected to the public Broadband Integrated Services Digital Network (B-ISDN). This protocol, partially based on DQDB, is currently one of the candidates for the CCITT standard for Generic Flow Control protocol which will regulate access to a shared medium in the B-CPN.

Mobile networks are also receiving attention. Teletraffic studies of cellular mobile networks aim to increase the maximum traffic density that can be handled, ensure a high quality of service, keep costs low, and achieve the best use of scarce radio spectrum resources. Although equipment for Telecom's MobileNet is manufactured in accordance with accepted standards, Telecom must still optimise the relations between service, quality, and traffic capacity. This is also the case for digital GSM networks which have many more traffic handling options than the current analog MobileNet. Teletraffic researchers at TRL have been examining the signalling traffic requirements in future GSM networks and have proposed several methods for progressively improving the handover performance.

One of the important steps in designing new networks is to predict and model the nature of the traffic to be transmitted on such networks. Proper traffic modelling is essential in network dimensioning and during network operation. Modelling traffic of modern networks such as B-ISDN is far more complex than modelling traffic in circuit switched telephone networks. In circuit switched telephone networks, all calls require the same amount of capacity, which stays fixed during the call. By contrast, modern packet switched networks and the future B-ISDN, exhibit large variation in their call capacity requirements, and may generate highly correlated bursty traffic streams.

Traffic models which took into account such burstiness and correlation have been proposed in the past, but were not amenable to analysis and not very useful in network design and dimensioning. This problem of traffic modelling and performance evaluation of B-ISDN is complex and has been considered one of the most important teletraffic research challenges during the last decade. Inspite of extensive research work on this topic throughout the world, no traffic model which will exhibit adequately the burstiness and correlation of B-ISDN, has previously been found to be amenable to mathematical analysis.

Recently, TRL has made a major breakthrough in this important area of research. New results in queuing theory show that it is possible to obtain closed form formulae for queuing systems fed by Gaussian processes. The Gaussian process is an ideal model for bursty traffic because it is general, in that it can exhibit arbitrary correlation and burstiness, and it is closed under superposition. This means that unlike other proposed models the difficulty of computing performance measures does not increase markedly as the number of superposed processes are increased. This work allows network dimensioning and efficient operation to be carried out.

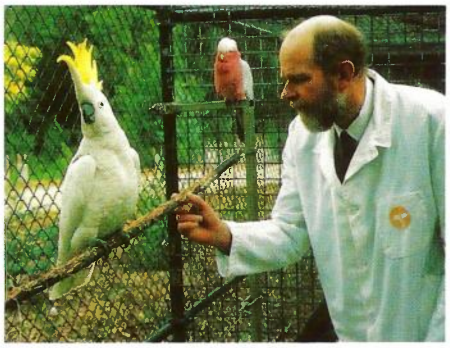
TRL continues to develop and experiment with new computing technologies to provide Telecom with an effective means of applying teletraffic theory to the telecommunications business.

Timely and relevant advice regarding new and existing technologies is transferred from TRL to client units in the customer divisions and other areas of Telecom Australia.

TECHNOLOGY AND INFORMATION TRANSFER

TRL ensures that Telecom Australia has timely and relevant advice regarding new and existing technologies. Know-how is transferred to client units in the customer divisions and other areas of Telecom Australia, and is applied in specific projects relating to the planning, implementation or operation of networks and services. Such processes of technology and information transfer are on-going and multi-faceted and are an important part of Telecom Australia's responsibility as the provider of telecommunications services throughout Australia.

Technical reports, papers, journals, and seminars communicate and document significant technological outputs arising from TRL's R&D programme. Audiences are wide and varied. They include industry, academe, external research and development organisations, Telecom management, Telecom customer divisions and their clients, and Telecom staff – information is transferred around Australia and to the four corners of the world.



Seminars and conferences convey, on a more personal level, the types of R&D TRL is engaged in, and the direction that research is leading telecommunications developments for business and the community at large.

Other formal and informal processes provide avenues for technology and information transfer to and from TRL. Collaborative R&D contracts and sponsorships enlist assistance from both industry and academe. Less formal peer group interactions also take place.

Involvement on standards committees and organisations at the national and international arenas ensures that Telecom's research is in line with world directions or even leading the way.

Intellectual property licences are negotiated with external organisations for the commercialisation of inventions and other forms of intellectual property arising out of work done by TRL and other parts of Telecom.

Over the past year TRL has seen many important examples of technology and information transfer. Some of the more significant examples are illustrated throughout the following pages which provide an insight into the importance Telecom Australia places on communicating and transferring technological information.

The PDF is supporting the development of ISDN networking for the real estate system being demonstrated here by Bill Hegarty of CDS.

The Telecom Australia Product Development Fund

The PDF has now been in operation for over five years and continues to provide Australian companies with a valuable source of finance and technical advice for their new development projects. As concrete examples of the fund's work it is pleasing to report on the continuing success of some of the first products to receive support.

Myles Hampton-Chubb and Associates has further expanded its printed internal directory business with the launch of a new company, "Corporate Telephone Directories" and is looking to establish an overseas office. CTD clients include Telecom as well as many others which feature in the list of Australia's top 100 companies.

Ausmode Rectifier Developments has become part of the Exicom Group and is now Exicom Power Systems. The company's range of products has increased and been exported to locations as diverse as Japan, Thailand, Pakistan, Vietnam, Singapore, Western Samoa, Papua New Guinea, Hong Kong and New Zealand.

Teletech Pty Ltd has sold over 8000 of their "Loop-a-Line" test instruments to Telecom and exports have been made to many countries including substantial quantities to NZ and the UK.

These are examples of the long term benefits of the PDF and they provide considerable encouragement for companies in the midst of new developments. Companies such as Central Picture Systems (CPS) and Mosaic Electronics are being helped by the resources of the Fund to develop new applications for the Integrated Services Digital Network (ISDN). PDF support together with Telecom's leading role in the implementation of ISDN networks means that these companies have the opportunity to produce world leading products.

CPS is developing a system which will use the ISDN for the Real Estate industry and provide customers with the opportunity to inspect images of properties from the comfort of an agent's office. The system has the potential to operate not only between suburbs of one city but also between areas Australia-wide.

Mosaic, which is the first Queensland company to be supported by the PDF is developing an ISDN interface for their range of computer-based electronic cash registers. Mosaic expects that this will provide businesses with the opportunity to improve productivity and communications.

Telecom's commitment to the PDF has been strengthened with its incorporation in the Telecom Industry Development Plan. This is indicative of Telecom's willingness to work with local industry to support new companies with energy, expertise and innovative ideas.

National Information Resource Centre

Information, properly managed, can assist an organisation to realise its full potential and achieve its corporate vision instead of merely performing its existing operation more efficiently. An important part of maintaining the competitive edge in the business environment involves providing high quality, value added, strategic information products and services.

In a large, geographically scattered company such as Telecom, the provision and management of information presents a number of challenges. For Telecom, which is both technically and commercially oriented, the successful management of information requires high level information skills together with a thorough knowledge of the organisation. The National Information Resource Centre (NIRC), established within TRL, is a focal point for the management of information throughout Telecom. Established in mid 1988 in response to the technical needs and the competitive commercial orientation of Telecom, the NIRC is provided by TRL as a corporate facility, on behalf of Telecom. Centres are located at TRL, and in major metropolitan areas throughout Australia. It aims to provide high-tech, high quality, enhanced information services to Telecom.

The NIRC is Telecom's access point for a wide range of information, both internally and externally generated. This information is vital for the key decision makers and strategic planners who need to be aware of the current commercial and technological environments in which Telecom is operating.

The physical distribution of its staff and collections throughout Telecom makes the NIRC heavily dependent on high-tech information handling techniques. The speed with which new technologies such as image storage and retrieval systems and broadband communication links are made available within Telecom will influence future developments in information management throughout the organisation.

The NIRC has a staff of highly skilled information professionals with a wide range of expertise in many aspects of information handling. These staff have also developed a thorough working knowledge of Telecom, and this knowledge is essential if they are to provide clients within Telecom with superior information products and services, relevant to the needs of the organisation.

CD-ROM is one of the many technologies used by Telecom's NIRC.

Kym Diprose and David Feighan of the National Information Resource Centre use high-tech retrieval equipment to provide strategic information for the whole of Telecom Australia.

The NIRC provides a full range of information products and services which have been tailored to be of specific value to Telecom people. Products and services are largely based on acquiring information from external sources, then analysing and packaging that information so that it meets the needs of particular client groups. General products and services are based on:

- Access to several thousand data bases, covering a comprehensive range of subjects of interest to Telecom. These include extensive information in science and technology and in business information.
- Access to an increasing range of information available via CD ROM.
- Access to extensive collections of information materials, of relevance to a wide range of Telecom activities. They include large collections of standards, integrated circuits/semiconductor files, business intelligence files and an excellent collection of hard copy reference tools, journals and conference proceedings.
- Consultancy and computer support services, relating to the management of information by Telecom people.
- A range of publications, available in paper copy or electronically, produced by the NIRC, for the use of all Telecom staff. These include Daily News Bulletin, Infotopics, Update, Conference Lists etc.
- A number of specialised value added business information products and services which contain strategic information for the use of key decision makers in the organisation. These include Infopackage, Competitor Watch, Business Monitor, Global Telecom Alert and R&D Report.
- Use of a wide range of equipment to ensure the availability of products and services in appropriate, high quality formats and in a timely manner.
- In-house data bases that include details of: Telecom Australia/PMG publications, annual reports from many Australian and overseas organisations, market research reports commissioned by Telecom, details of forthcoming conferences, both Australian and international in science and technology and in management, and marketing current journal articles, and items of interest to Telecom selected from the daily press.
- A limited range of traditional library services.

The NIRC aims to provide products and services that are relevant to the needs of Telecom people, and of significance in assisting Telecom to maintain a competitive position in the market place. Our range of products and services changes as a result of changes to the organisation.

Increasingly, a range of value-added products and services is being sought by our clients. These enhance the worth of the information provided by the NIRC and assist senior clients in their decision making. Many of these products relate to business information, and the NIRC now has considerable professional expertise in the provision of business information products.

Centre of Expertise Contract Renewed

TRL has recognised the excellent research work done at the Centre of Expertise in Distributed Information Systems (CEDIS) by agreeing to support the Centre for a further three years.

This Centre was originally established at the University of Queensland in 1988 for studies on distributed information systems. These systems employ databases at various points of the telecommunication network, and the work examined ways of ensuring that data is readily available to all parts of the network and capable of being updated no matter where in the network it is currently stored. These studies have been beneficial to services such as directories and other network control systems.

The new contract calls for research work to concentrate on the effective application of software technology to database design and distributed interworking of databases relevant to telecommunication services applications and telecommunications network management. The principal topic areas are:

Distributed Database Design – the development of design methods and tools and their validation in such application as spatial information systems, intelligent networks, directory services and network management systems.

Open Distributed Processing (ODP) and Trader – the use of ODP techniques as generic components for building distributed systems and participation in Australian and international standards committees to produce an early implementation of the Trader standard.

Concurrency Control – the implications of concurrency control schemes on the design of intelligent networks and X.500 directory services.

State-of-the-art watching brief – on internationally significant conferences, published papers and developments in theory and practice in this field.

TRL is pleased to recognise the excellent work of this Centre and looks forward to a continuing successful assocation with the University of Queensland during the next three years. The Centre of Expertise in Distributed Information Systems has demonstrated the value of TRL's Centre of Expertise philosophy which seeks to match Telecom's needs for research in important telecommunications topics with academic skills in the tertiary education sector.

TRL Supports Co-operative Research Centres

TRL is a partner in two of the Co-operative Research Centres (CRCs) which were announced by the Government in December 1991. The objective of the CRC scheme is to increase the effectiveness of research and teaching in Australia by bringing together higher education institutions, government research institutions (such as CSIRO), and industry. TRL's proposed input to these CRCs is mainly by contract for specific R&D work and by sharing of knowledge. In addition, some parts of TRL's work programme are available to the participants in the CRC under conditions where TRL retains control of the work.

TRL is negotiating the detailed agreements with the Commonwealth Government and the other participants to define the scope of our participation and the ways in which intellectual property will be controlled within the CRC. The two CRCs and the parties which are supporting them are:

Co-operative Research Centre for Distributed System Technology – University of Queensland, Digital Equipment Corporation, Queensland State Government, Defence Science and Technology Organisation, Queensland University of Technology, Bond University, Telecom, Griffith University, Jtec Pty Ltd, University of Technology Sydney.

Australian Photonics Co-operative Research Centre – Universities of Sydney and Melbourne, Australian National University, University of NSW, Australian Computing & Communications Institute, Broken Hill Proprietary Ltd, Fibernet Pty Ltd, NEC Pty Ltd, Siemens Ltd, Telecom, CSIRO, Electricity Commission of NSW.

In addition, TRL has provided considerable assistance to the Jindalee Project Office in setting up the arrangements for its participation in the following CRC with the other parties as shown:

Co-operative Research Centre for Sensor Signal and Information Processing - Universities of South Australia, Adelaide, Flinders, Melbourne, and Queensland, the Defence Science and Technology Organisation, Telecom (Jindalee Project Office), Digital Equipment Corporation.

Telecommunications Software Research Centre

As part of our commitment to supporting strong, focused research in Australia, Telecom opened the Telecommunications Software Research Centre at the University of Wollongong in July 1991. This is the sixth Centre to be funded by Telecom as part of its Centre of Expertise scheme which matches Telecom's research needs with nationally recognised research groups who demonstrate a commitment and capability to develop a particular topic and who can transfer the skills to graduates and postgraduates.

The Telecommunications Software Research Centre conducts R&D in three areas of telecommunications software with specific emphasis on software engineering techniques which were originally developed for computer systems. An essential outcome of this work is the application of these techniques to the design of distributed telecommunications networks. The three specific topics are:

Information Modelling – the application of object-oriented techniques for the implementation of real-time event driven systems and the development of management models for integrated networks based on the reference Model for Open Distributed Processing;

Service Management – the development of consistent design techniques, emphasising the facilities required for customer premises equipment, and the implementation of service creation environments utilising object-oriented design techniques;

Information Networking Architectures – a specific network service such as the UPT service will be characterised in terms of an operating system model which will then be extended to cover all parts of the service in a consistent fashion.

The work of this Centre is supported by a three year contract. Funding for the contract is provided by Telecom's Network Products Business Unit and supervision of the research work is undertaken by the Switched Networks Branch of TRL.

FORTE'91 International Conference Sponsored by Telecom and OTC

TRL's participation in FORTE'91, the Fourth International Conference on Formal Description Techniques, places Telecom Australia in a strong position to gain commercial advantage from the use of the latest protocol engineering tools and techniques as they mature. TRL's involvement will help save time and money by giving Telecom first-hand knowledge of application of formal techniques to the development of reliable, flexible, and maintainable communications software.

Telecom and other Australian participation in FORTE'91 is helping build a technology resource for the design and development of quality, leading-edge software to aid technical problem solving. This is crucial for Telecom's business success.

Telecom, with the University of Queensland, jointly chaired the conference which was held at OTC in Sydney. Sponsors included Telecom, OTC, and professional sponsorship by IFIP TC6/WG6.1 with the co-operation of IEEE (Vic.). The focus was on the development of formal description techniques and their application, particularly to communications and distributed systems. Presentations included Prof. Simon Lam's exposition of his theory of interfaces and recent AT&T experience using formal methods for telephone exchange software development.

Success of the conference was indicated by the enthusiastic participation of over 90 people from 14 countries. FORTE'91 was officially opened by Peter Rehn, MD of Computer Sciences of Australia, followed by Dennis Mullane, Broadband Services Manager in Telecom, and Don Nicol, Chief of OTC R&D. The three significant invited papers by Prof. Ed Brinksma (Holland), Prof. Simon Lam (USA) and Prof. Ralph Back (Finland) were well received. They were complemented by the 33 refereed papers presented (selected out of 71 papers submitted) showing the worldwide use of formal techniques including LOTOS, Estelle, SDL, Petri-Nets and Z.

Stimulating panel discussions were chaired by Prof. Ken Turner and Michel Diaz. International experts presented 7 valuable tutorials including the use of several techniques for the practical development of protocols. There were demonstrations of a variety of software tools from around the world based on formal techniques, including Telecom's TORAS and PROMPT tools in the FORSEE toolset.

Many people contributed to the success of FORTE'91 including, previous FORTE chairperson, the Programme Committee, and representatives from OTC, Telecom and the University of Queensland. The University of Queensland, Computer Sciences of Australia, Ericsson, and Sun Microsystems (Australia) provided equipment.

The proceedings of FORTE'91 have been published by North-Holland Elsevier as "Formal Description Techniques, IV", edited by the FORTE'91 Co-chairpersons Ken Parker, TRL, and Prof. Gordon Rose, University of Queensland.

Intellectual Property

For many years TRL has managed Telecom's portfolio of patents and registered designs, and provided a broadly based intellectual property consultancy service to Telecom's Business Units. Following the rationalisation of Telecom's Corporate Centre, this activity has now been expanded to include the provision of formal legal advice in relation to intellectual property issues, and the assumption of responsibility for the management of Telecom's trade mark portfolio.

With the transfer of personnel from the Corporate Centre and the recruitment of a trade mark specialist from private practice, TRL now offers the Corporation a full range of intellectual property services, including:

- Complete management of statutory intellectual property (trade marks, patents and registered designs).
- Advice and assistance in relation to copyright and the protection of confidential information.
- Advice and assistance in the negotiation and preparation of a wide range of commercial agreements, research and development agreements and intellectual property licences.
- Protecting the Corporation's interests in the event of intellectual property disputes, such as trade mark infringements, misuse of confidential information.
- Education of management and staff on intellectual property, through the conduct of regular seminars and workshops.

TRL also represents the Corporation's interests on a number of committees dealing with intellectual property issues.

International Workshop at TRL on Computational Electromagnetics

In August, 1992, TRL hosted a Workshop on computational electromagnetics (CEM) with the theme 'Directions for the Nineties'. The Workshop, scheduled between the Asia-Pacific Microwave Conference and the 14th Triennial URSI Symposium, was the first such meeting within Australia, and received wide support both internationally and locally. In fact, this was the first Workshop organised outside the U.S.A. run under the auspices of the Applied Computational Electromagnetics Society (ACES).

The programme presented a timely survey of computational efforts in code development and application, matched to present and emerging needs to the end of the decade. The Workshop format included presentations by eminent international speakers, audience participation, and specialised CEM software demonstrations. Among the invited speakers were Dr Ed Miller from Los Alamos National Laboratory, New Mexico, Mr Gerry Burke from Lawrence Livermore Laboratories, California, Prof. Tapan Sarkar from Syracuse University, New York, and Prof. Bach Andersen from Aalsborg University, Aalsborg. This was

An exhibitor at the International Workshop on Computational Electromagnetics demonstrates Finite Element Method (FEM) software to Harry Wragge and the international speakers.

an excellent opportunity for local CEM practicioners to benefit from the experience and insight of these experts, to discuss applications, and to become aware of latest trends in the development of a variety of codes including NEC (Numerical Electromagnetics Code).

Broadband Symposium

In July, TRL co-hosted the 1992 Australian Broadband Switching and Services Symposium which was held at Monash University. The two-day symposium attracted over 200 delegates from the computing and telecommunications industries who heard of progress in the development of broadband networks and video-based services.

Several leading international speakers attended the symposium, including Prof. Jonathon Turner of Washington University, and Dr Didier Le Gall of C-Cube Microsystems. Dr Le Gall is also Vice Group Chairman of the ISO Moving Picture Experts Group (MPEG) – a group responsible for the international standardisation of video coding methods. He and Australian MPEG representatives flew direct from the latest MPEG meeting in Rio de Janeiro to attend the symposium and were able to provide delegates with up to date reports of developments.

The symposium also provided a forum for the unveiling of a Universal Video Coding (UVC) system which has resulted from two years of intensive collaborative work by researchers from TRL, Siemens Ltd, Monash University and the Australian Defence Force Academy. The UVC system can distribute a common digital video signal to a wide variety of terminals ranging in quality from videotelephones to high definition television systems. Consequently, the UVC concept can save customers money by allowing them to use a single terminal to receive many different video-based services.

In his opening address to the symposium, The Chief Executive Officer of Telecom, Frank Blount, contrasted TRL's leadership in research and development with the increased emphasis on marketing in the newly deregulated telecommunications industry. "R&D and sales and marketing are aspects of the same continuum," he said, "and both are crucial to success in the years ahead. The truth is, however, that our business is not equally well-endowed in each part of the continuum. But that is changing, and I aim to see the day when the excellence that is evident in our technology is matched across the whole spectrum of our business."

Visit by Chief Executive Officer

Telecom Australia's new Chief Executive Officer, Frank Blount, made his first visit to TRL in 1992, and took the opportunity to meet with TRL staff and answer questions. In front of a capacity crowd in TRL's 400 seat auditorium, the great majority of TRL staff heard the organisation's top manager address issues that ranged from the future role of research and development in Telecom to equal opportunity and staff redundancies.

Mr Blount has made arrangements to visit TRL on a regular monthly basis so that he can keep abreast of emerging telecommunications technologies.

Researcher Dr Gavern Rossman demonstrates TRL's optical fibre drawing tower to Frank Blount and Harry Wragge.

Frank Blount addresses staff in TRL's 400 seat auditorium.

1992 Fellowship students accept their awards at TRL.

TRL Fellowship Awards

TRL continued to give financial assistance to high quality university students and staff in 1992.

Ten Australian and six New Zealand undergraduate students studying in telecommunications-related fields were awarded Telecom Australia Undergraduate Fellowships in January. The Australian Fellows each received stipends amounting to $7,500 to assist them through their final year of undergraduate study. They were also offered paid research work at TRL during the 1991/92 Christmas vacation period. The New Zealand Fellows had their final year university fees paid, and were provided with return airfares to Australia and accommodation and meals in Melbourne so that they too could gain first hand experience working at TRL.

The Undergraduate Fellows were presented with their certificates by the Acting Director of Research, Mr Jim Park, at a ceremony attended by their friends and relatives, as well as senior researchers from Monash and University of Melbourne and TRL. Mr Park said that the Fellowships Programme encouraged "future leaders in the field" and helped to maintain Telecom Australia "as a world force in telecommunications".

TRL also presented four Telecom Australia Postgraduate Fellowships in 1992. These are valued at $11,000 for each year of postgraduate study and are awarded to outstanding students who are undertaking postgraduate research relevant to the interests of TRL. Short Term Fellowships were also awarded to selected academic researchers who spent six weeks at TRL working on projects of mutual interest.

International Mathematical Olympiad

Australia achieved outstanding success at the 33rd International Mathematical Olympiad held in Moscow in July. Secondary school students from 56 countries competed in the event with the six member Australian team taking out one gold, one silver and two bronze medals plus an honourable mention. The Australian team was sponsored by The Department of Education Employment & Training, Telecom Australia and IBM Australia Ltd.

Prior to their departure for Moscow, TRL hosted a special farewell ceremony for the Australian team. In front of an audience comprising relatives and friends of the team members, senior academics, TRL staff, and members of the Australian Mathematical Olympiad Committee. The team was presented with their air tickets to Moscow by Dr Richard Telford, a Director of the Australian Institute of Sport. The Hon Warren Snowdon MP, Parliamentary Secretary to the Minister for Transport and Communications, also attended and bid the team members every success in their endeavours.

The Flame of Science

A major highlight of the farewell ceremony for the Australian International Mathematical Olympiad team was the inaugural lighting of Australia's Flame of Science by one of the team members. The spirit and purpose of the Flame is embodied in its accompanying inscription:

The Flame of Science symbolises the creative excellence that burns at the heart of Australian science and technology. It is the fire that kindles curiosity in the human mind, and lights the path that leads on to our greater knowledge and understanding.

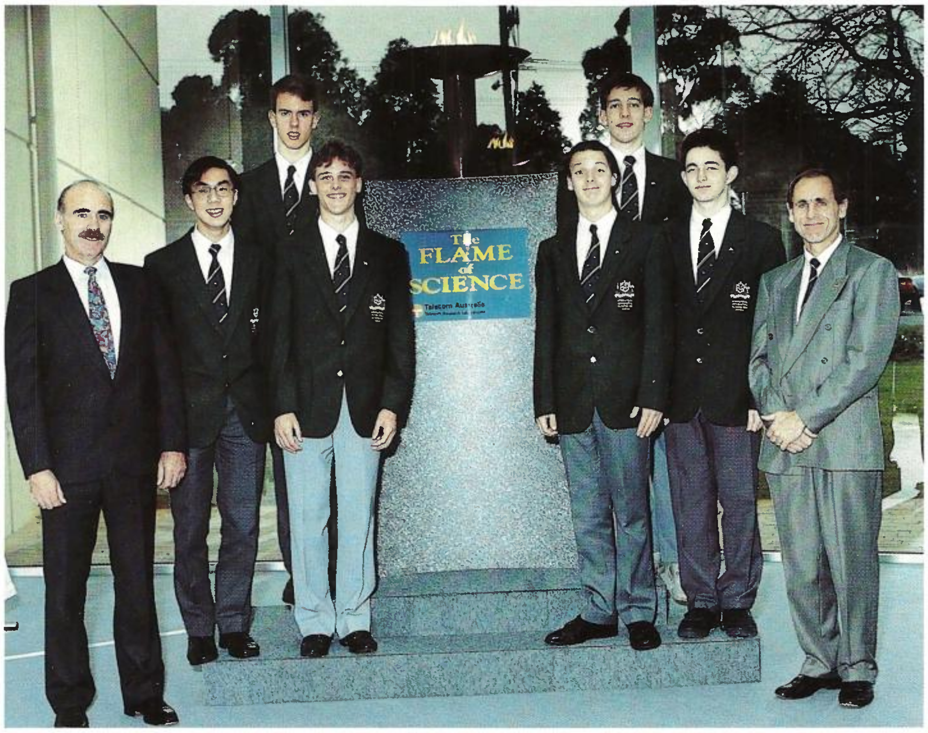
The Mathematical Olympiad team was representative of Australia's traditional dedication to the pursuit of excellence. It is therefore fitting that the Flame be taken to Canberra in March 1993 to herald the opening of the inaugural Australian Science Festival and Conference. This major national forum will bring together representatives from the scientific fraternity, industry and the community to focus on the important role of science in shaping Australia's economic development and prosperity.

Australian Multimedia Conference at TRL

TRL hosted the 2nd Australian Multimedia Communications, Applications and Technology Workshop in July. The Workshop aimed at providing a forum for researchers, users and vendors in the growing and important field of multimedia. The emphasis was on technological developments and the applications of multimedia technolgy.

The Workshop was opened by Harry Wragge, Director of Research, TRL. The keynote address was delivered by Dr Bryan Ackland, Head of VLSI Systems in AT&T Bell Laboratories, USA. Dr Ackland discussed the latest VLSI developments in multimedia technology, and how such developments will drive the commercial availability of very low-cost multimedia systems.

A total of 26 papers were presented over two days by Australian and overseas authors. The papers covered applications, human factors, communications and the design of multimedia systems. Invited presentations were given by IBM Australia and the Australian Computing and Communications Institute. The latest equipment and research prototypes were



Hon. Warren Snowdon MP (left), Secretary to the Minister of Communications, and Dr Richard Telford (right), from the Australian Institute of Sport, help farewell the Australian Mathematical Olympiad Team at Telecom Research Laboratories on July 6, 1992. The team returned from the Commonwealth of Independant States, bringing with them one gold, one silver, two bronze and an honourable mention.

From left: Hon. Warren Snowdon, Lawrence Ip, Anthony Henderson, Ben Burton, Rupert McCallum, Frank Calegari, Adrian Banner, Dr Richard Telford.

demonstrated by vendors and research institutions, including live demonstrations of multimedia conferencing and retrieval services utilising Telecom's Fastpac and ISDN networks.

The Workshop was very successful in attracting about 200 delegates from a wide range of disciplines. The range of backgrounds of delegates was unusual for a technical workshop – a reflection of the importance of multimedia technology as a basis for future services that will extend to many different customer groups.

NASA Visit

Among the many international visitors to TRL in 1992 was William Johnson, (pictured below) the Chief Engineer of NASA's Jet Propulsion Laboratories in the United States. He and other senior NASA staff made a presentation to an audience of 440 people comprising TRL staff and members of the Astronomical Society of Victoria (ASV). Entitled *The Unveiling of Venus*, the presentation provided details of NASA's recent Magellan mission to Venus, and showed new radar-derived images of the planet's surface.

Obituary

James Hubert Thomas Fisher

1911-1992

Review of Activities regretfully records the passing of Jim Fisher, a telecommunications researcher who pioneered the introduction and development of television services in Australia. Mr Fisher developed a keen interest in the concept of television soon after commencing engineering studies at the University of Adelaide in 1929. He joined the Postmaster-General's Department (PMG) as a cadet engineer in 1930 and, after qualifying in engineering, moved to Melbourne in 1936 to work in the PMG Research Laboratories – the precursor of Telecom Research Laboratories.

The Research Laboratories imported many technical publications which reported on the early television experiments and trials then underway overseas. Mr Fisher read these avidly, and so began to prepare both himself and his country for the advent of television services twenty years before their introduction.

In 1937, to raise awareness of television within the Australian engineering fraternity, he prepared a paper entitled *Recent Developments in Television* which he presented to the Juniors and Students Section of the Institution of Engineers, Australia. He illustrated the principles involved by demonstrating a hand-built television system of his own design. Rudimentary though it was, his system was as technically advanced as any in the world at that time.

In 1938, Mr Fisher prepared the first of many reports on television for the Commonwealth Government. This one, entitled *A Study of Overseas Developments in Television, in Relation to Possible Future Services in Australia*, made a comprehensive forecast of the necessary characteristics, and probable costs, of establishing a television service in the Melbourne area.

World War II then interrupted Mr Fisher's television research and he was redeployed to urgent and secret development work on radar. In 1940 he was given responsibility for co-ordinating the design and manufacture of Australia's anti-aircraft Shore Defence Systems, and following this, in 1942, he was assigned to work on radar-guided searchlight systems. He excelled in both projects.

After the war, there was considerable pressure for Australia to adopt Britain's low definition television picture standard of 405 lines as the basis for future services. However, Mr Fisher disagreed. In a 1948 report entitled *Suggested Picture Definition Standards for Television Broadcasting in Australia* he concluded that the British system was lagging behind in technical development, and he put forward the radical proposal for a higher resolution system of 625 lines. He was the only Australian to take such a stand at this time, and he can be credited with giving Australia the high quality television pictures it received when services eventually commenced.

Jim Fisher *circa* 1956

Following another report in 1949, this time detailing projected television services for the Sydney area, Mr Fisher travelled to North America and Europe to investigate the provision of television services in other countries. Returning to Australia, he began training people for employment in the future television industry. From 1951 to 1956 he gave evening lectures in television technology and production at what later became the Royal Melbourne Institute of Technology. Two of his students were Hector and Dorothy Crawford who went on to found one of Australia's leading television production houses.

Mr Fisher left the PMG in 1954 to become Engineer-Television in the Australian Broadcasting Control Board where he wrote Australia's first formal technical standards for television broadcasting. A year later he left the Board to become the first Chief Engineer of Channel HSV-7 in Melbourne where he managed the design, procurement, construction and operation of all studio, production and transmission facilities.

When television services commenced in 1956, Mr Fisher was at once an old hand in a new industry. His knowledge of television, both as a technology and as a medium of entertainment, was trusted and deeply respected. His advice was sought not only by the industry's engineers and technicians, but also by its station executives, producers and on-air personalities. He remained HSV-7's Chief Engineer until he retired in 1977, but continued his involvement in several major national and international technical forums.

In 1986, the Television Society of Australia presented Mr Fisher with its Colin Bednall Award. The award's citation read in part: "No other single person can be credited with contributing so much over so many years to the national and commercial broadcasting structure, and to the technical excellence of Australia's television industry." In 1989 he was awarded a special Paul Marlan Award by the Federation of Australian Commercial Television Stations (FACTS) for his pioneering work in television, and for his long and distinguished service on the FACTS Engineering Committee.

Those who worked with Jim Fisher remember him as a polite and genial character whose cultivated sense of humour could discover the lighter side of difficult and complex situations. He was also endowed with a genuine humility, and a keen desire to share his knowledge with others. To many he became known simply as 'Gentleman Jim' – a man who was born for research work, and a man who was made for his times.

ACKNOWLEDGEMENTS

Manager, Promotion and Communication

Brian Donovan (03) 253 6200

Editor/Project Manager

Keith Ritchie (03) 253 6691

Photography

Andrew Lucas

Design & Production

Brian Pascoe Design
South Melbourne
Victoria

Colour Separations

Scott Graphic Arts
Collingwood
Victoria

Printing

York Press
Richmond
Victoria

Telecom Australia
Research Laboratories